Rapid Construction of the Canadian Pacific Railway.*

BY A. T. ABBOTT.

During the winter of 1881 and 1882 the contract was let to Messrs. Langdon, Sheppard & Co., of Minneapolis, to construct during the working season of the latter year, or prior to January 1, 1883, 500 miles of railroad on the western extension of the above company; the contract being for the grading, bridging, track laying and surfacing, also including the laying of the necessary depot sidings and their grading. The idea that any such amount of road could be built in that country in that time was looked upon by the writer hereof, as well as by railroad men generally, as a huge joke, perpetrated to gull the Canadians. At the time the contract was let the Canadian Pacific Railway was in operation to Brandon, the crossing of the Assiniboine river, 132 miles west of Winnipeg. The track was laid, however, to a point about 50 miles west of this, and the grading done, generally in an unfinished state, for 30 miles further. This was the condition of things when the contract was entered into to build 500 miles—the east end of the 500-mile contract being at station 4,660 (station 0 being at Brandon) and extending west to a few miles beyond the Saskatchewan river.

The spring of 1882 opened in the most unpromising manner for railroad operations, being the wettest ever known in that country. Traffic over the St. Paul, Minneapolis and Manitoba Railroad, between St. Paul and Winnipeg, was entirely suspended from April 15 to the 28th, owing to the floods on the Red river at St. Vincent and Emerson, a serious blow to an early start, as on this single track depended the transportation of all supplies, men, timber and contractors' plant, together with all track materials (except ties), all of these things having to come from, or through St. Paul and Minneapolis. The writer hereof was appointed a division engineer, and reported at Winnipeg the 15th of April, getting through on the last train before the St. Vincent flood. No sooner was the line open from St. Paul to Winnipeg than the cotillion opened between Winnipeg and Brandon, with a succession of washouts that defied and defeated all efforts to get trains over, so it was not until the fifth day of May that I left Winnipeg to take charge of the second division of 30 miles.

By extremely "dizzy" speed I was landed at the end of the track, 180 miles from Winnipeg, on the evening of the 9th (four days). My outfit consisted of three assistant engineers, and the necessary paraphernalia for three complete camps, 30 days' provisions (which turned out to be about 20), 11 carts and ponies, the latter being extremely poor after a winter's diet on buffalo grass and no grain. On the 18th day of May I had my division organized and camps in running order. The country was literally under water, dry ground being the exception, and I look upon the feat of getting across the country at all as the engineering triumph of my life.

On May 20 a genuine blizzard set in, lasting 24 hours, snowed five inches, and froze the sloughs over with half an inch of ice, a decidedly interesting event to the writer, as he was 18 miles from the nearest wood; therefore laid in his blankets and ate hard tack. I stabled my ponies in the cooks tent, and after they had literally eaten off the sod inside the tent I divided my floor with them.

On the 28th day of May I saw the first contractor, who broke ground at station 7,150. On the 1st, of June I was relieved from this division and ordered to take the next, 50 miles west. On the 13th day of June ground was broken on this division at station 8,070, or only about 62 miles west of the east end of the 500-mile contract. It looked at this time as though they might build 150 miles, but not more. But from this on very rapid progress was made. On July 17 the track reached station 7,000, making however, up to this time but about 50 miles of track-laying, including that laid on the old grade; but large forces were put on to surfacing and the track already laid was put in excellent condition for getting material to the front. The weather from this until the freeze-up was all that could be desired. Work ceased about the 1st of January, 1883, for the season, and the final estimate for the work was as follows: 6,103,986 cubic yards earth excavation, 2,395,750 feet B. M. timber in bridges and culverts, 85,708 lineal feet piling, 435 miles of track-laying. This work was all done in 182 working days, including stormy ones, when little, if anything, could be done, making a daily average of 33,548 yards excavation, 13,150 feet B. M. timber, 471 feet piling, 2.38 miles track-laying. We never had an accurate force report made of the whole line, but roughly there were employed 5,000 men and 1,700 teams.

The admirable organization of the contractors was something wonderful. The grading work was practically all done by sub-contractors, Messrs. Langdon, Sheppard & Co. confining themselves to putting in the supplies and doing the bridge work, surfacing and track-laying. The grading forces were scattered along about 150 miles ahead of the track and supply stores, established about 50 miles apart, and in no case were sub-contractors expected to haul supplies over 100 miles. If I remember rightly there were four trains of about 40 wagons each, hauling supplies from the end of track to the stores.

As can be easily seen, the vital point of the whole work and the problem to solve was food for men and horses. One thousand seven hundred bushels of oats every day, and 15,000 pounds of provisions, Sundays and all, for an entire season, which at the beginning of the work had to come about 170 miles by rail, and then be taken from 50 to 150 miles by teams across a wilderness, is on the face of it considerable of an undertaking, to say nothing about hauling the pile-drivers, piles and bridge-timber there. To keep from delaying the track, sidings 1,500 feet long were graded, about seven miles apart. A side-track crew, together with an engine, four flats and caboose, were always in readiness, and so soon as a siding was reached, in five hours the switches would be in and the next day it would be surfaced and all in working order, when the operating department would fill it with track material and supplies. From the head of the siding to the end of the track the ground was in the hands of track-layers, the track-laying engine never going back of the last siding for supplies or material, and my recollection is that there was but six hours' delay to the track from lack of material the whole season, at any rate up to sometime in November. The track-laying crew was equal to four miles per day, and in the month of August 92 miles of track was laid.

The ties were cut on the line of the road about 100 miles east of Winnipeg, so the shortest distance any ties were hauled was 270 miles; the actual daily burden of the single track from Winnipeg west was 24 cars steel, 24 cars ties, aside from the transportation of grain and provisions, bridge material and lumber for station houses. The station buildings were kept right up by the company itself and a depot built with rooms for the agent every 15 miles, or at every second siding. The importance of keeping the buildings up with the track was impressed upon the mind of the superintendent of this branch, and as a satire, he telegraphed asking permission to haul his stuff ahead of the track by teams, he being on the track-layers' heels with his stations and tanks the whole season. The telegraph line was also built, and kept right up to the end of the track, three or four miles being the furthest they were at any time behind.

It might be supposed that work done so rapidly would not be well done, but it is the best built prairie road I know of on this continent. It is built almost entirely free from cuts, and the work is at least 20 per cent. heavier than would ordinarily be made across the same country in the States on account of snow. Two thousand six hundred and forty ties were laid to the mile and the track ballasting kept well up with the laying; so well, in fact, and so well done that as 100 mile sections were completed schedule trains were put on 20 miles an hour, and the operating department had nothing to do but make a time table; the road was built by the construction department before the operating department was asked to take it. The engineering was organized in divisions of 30 miles each, and as each was finished the parties moved ahead again to the front, the engineers usually finding men sitting on their shovels waiting for the work to be laid out for them. It was as much as the locating parties could do to keep out of the way of the construction. The road-bed was built 14 feet wide in embankment and 20 in the very few cuts there were, there being no cuts of any moment except through the Coteaus and the Saskatchewan crossing, and these have since been widened out on account of snow, so that the road can be operated the year around and the bucking-snow account cut no figure in the operating expenses.

The country is a virgin desert. From Winnipeg to the Pacific ocean there are a few places that might attain to the dignity of an oasis—at Brandon, Portage la Prarie, etc., but it is generally what I should call worthless, 100 miles to wood and 100 feet to water was the general experience west of the Moose-jaw, and the months of June, July and August are the only three in the year that it is safe to bet you will not have sleighing. I burned wood and used stakes that were hauled by carts 85 miles, and none any nearer. It is a matter of some pride that both the engineering and the construction were done by what our Canadian neighbors kindly termed "Yankee importations." However, there was one thing that in the building of this road was in marked contrast to any other Pacific road ever constructed that is, that there was no lawlessness, no whiskey, and not even a knock-down fight that I ever heard of the whole season, and even in the midst of 12,000 Indians, all armed with Winchester rifles and plenty of ammunition, not one of the locating or construction parties ever had a military escort, nor were any depredations ever committed, except the running off of a few horses, which were usually recovered, and I think there were but two fatal accidents during the season, one man killed on the Grand Coule bridge, and another from being kicked by a horse.

The track was all laid from one end, and in no case were rails hauled ahead by teams. Two iron cars were used, the empty returning one being turned up beside the track to let the loaded one by.

The feat in rapid construction accomplished by this company will never be duplicated, done as it was by a reckless expenditure of money, the orders to the engineers being to "get there" regardless of expense and horse-flesh; if you killed a horse by hard driving, his harness would fit another, and there was no scrutiny bestowed on vouchers when the work was done, and I must pay the tribute to the company to say that everything money would buy was sent to make the engineers comfortable. It was bad enough at best, and the Chief Engineer (J. C. James) rightly considered that any expense bestowed on the engineering part of the work was a good investment.

* Read before the Engineers Club of Minnesota. Reprinted from Journal of the Association of Engineering Societies.

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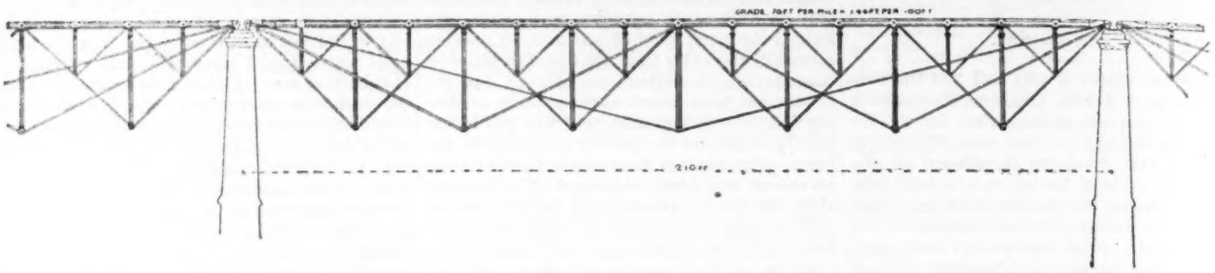
FIG. 1. LOUISVILLE BRIDGE; GENERAL DESIGN OF TRUSS.



The Movement in the Spans of the Louisville Bridge.

Written for ENGINEERING NEWS.

BY M. J. BECKER, CHIEF. ENG. P. C. & ST. L. R. R.

In a paper recently read before the St. Louis Engineers' Club, by Professor J. B. Johnson, of Washington University, and published as a supplement to the October number of the Journal of the Association of Engineering Societies, on the "Creeping of the Rails in the Track of the St. Louis Bridge and its Eastern Approach," reference is made to a movement of some of the spans of the Ohio River Bridge at Louisville, Ky.

Although I do not think that the movements observed in some of the trusses of the Louisville Bridge are due to any of the causes attributed to the creeping of the track on the St. Louis Bridge, yet, since the subject has been brought up, and has attracted some attention among members of the profession, it is perhaps well to discuss it more generally; and with that object in view I offer the following contribution describing the movements of the trusses of the Louisville Bridge, and giving my views as to the causes which produced them, with some remarks regarding the remedies that have been applied to prevent them in the future.

The bridge over the Ohio River at Louisville Ky., was built in 1869 by the Louisville Bridge Company, from the designs and, under the direction, of its Chief Engineer, Mr. Albert Fink. It consists of 2 spans of 50 feet each; 1 pivot draw over canal of 264 feet; 4 spans of 149 5/10 feet each; 2 spans of 180 feet each; 2 spans of 210 feet each; 2 spans of 227 feet each; 1 channel span of 370 feet; 6 spans of 245 5/10 feet each; 1 channel span of 400 feet; 3 spans of 100 each 1 span of 149 5/10 feet,and 1 span of 100 feet, counting the spans in their order as above given from the south shore of the river at the Kentucky side, to the north shore on the Indiana side; the piers are numbered in the same order of succession, and the spans are lettered in like progression. The general design of the bridge is shown on Fig. 1. The total length of the bridge is just one mile.

With the exception of the two channel spans, which are sub-divided triangular Warren girders, and of the draw span, which is of the regular triangular form, the entire bridge is of the well-known Fink type, the compression members being generally of cast-iron and the tension members of wrought-iron. In the channel spans and also in some of the larger intermediate spans, the posts are of wrought-iron, but the top chords are of cast-iron throughout the entire structure. All spans are under grade, except the two channel spans. It is but proper here to say, that the general plan is of most excellent design for that type of bridge; all details are of good finish, and the workmanship throughout is of the most perfect character; the quality of the material also, as far as it is possible now to determine, appears quite superior. As will be seen from the general profile, the gradient of the track rises from the Kentucky shore at the rate of 79.14 feet per mile for a distance of 2193 feet to the south end of the first channel span,

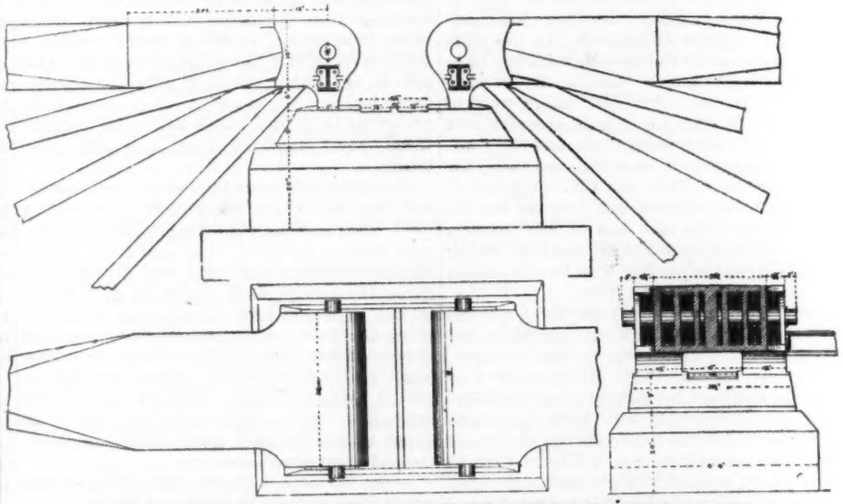


FIG. 2. LOUISVILLE BRIDGE; END BEARINGS OF DECK SPANS.

thence for a distance of 2,241 feet to the north end of the second channel span, the track is level; and from that point it descends at the rate of 78.6 feet per mile to the north end of the bridge.

The ends of all the deck spans rest upon cast-iron bed plates as shown in detail in Fig. 2.

I am told that soon after the completion of the bridge, movements became apparent in some of the deck spans, most noticeable on that part of the bridge located upon grades, and generally tending in the direction of the descent; but slight movements in both directions were also observed in some of the horizontal spans and in a few cases the movement tended upwards on some of the spans located upon the grades.

Efforts were first made to arrest these movements by wrought-iron straps fastened into the cast-iron bed plates by bolts and passed around the ends of the chords, placing the straps at those ends of the trusses on which the forward movement had been observed. But this contrivance resulted simply in either tearing the straps or causing a reverse movement of the trusses in the opposite direction.

The next attempt at arrest consisted in tying the two ends of adjacent spans together by cast iron hooks and wrought-iron rods as shown in Fig. 3, evidently on the supposition that the ends so tied would remain stationary, and the movement confined to the opposite ends, where it would come and go within the limits of the supporting surface of the bed plate. This attempt proved also a failure; the necks of the cast-iron hooks broke and in most cases tore the screw ends of the tie rods asunder close to the nuts.

As these failures are merely incidental results of the same primary cause which produces the movement in the trusses, it is not necessary to dwell here upon the reasons for the failures, and I will therefore proceed to the investigation of the primary cause, which I think will be found to explain not only the general movement, but also all incidental effects.

First then what are the facts in the case?

The bridge has but a single track, and the traffic is very nearly equally divided in both directions, so that the train movement would not produce any unequal effect upon the structure except what may be due to the grades; and since the track is not so rigidly connected with the structure, as to communicate to it any movement due to the traffic, it seems unreasonable to attribute the displacement of the trusses to that cause.

The creeping of the trusses always takes place during extremely hot or cold weather, showing that it is due to changes in the temperature, expanding by heat and contracting by cold.

Careful measurements made in December last, show the movements of the trusses from their original normal position upon the supporting plates to be as follows:

Span	D	moved	2 3/8	inches	southwardly.
"	E	"	3/4	"	"
"	F	"	7/8	"	"
"	G	"	1 1/8	"	"
"	H	"	1/8	"	"
"	I	"	1 3/4	"	"
"	K	"	2 1/8	"	"
"	L	"	1 1/8	"	"
"	M	"	1/8	"	"
"	N	"	3/4	"	Northwardly.
"	O	Channel Span.	No	Movement.	
"	P	moved	1 3/4	inches	Northwardly.
"	Q	"	1/8	"	"
"	R	"	7/8	"	"
"	S	"	1/8	"	"
"	T	"	1/8	"	"
"	U	"	1 3/8	"	"
"	Y	Channel Span.	No	Movement.	
"	W	moved	3/4	inches	Northwardly.
"	X	"	1 3/4	"	"
"	Y	"	1 1/8	"	"
"	Z	"	2 3/8	"	"
"	ZZ	"	3/4	"	

From these measurements it appears, that upon the grades all spans, except Span N, moved down the incline, and upon the level part of the bridge the movements were equally divided, 3 spans going northwardly and 3 spans going southwardly; showing conclusively, that the grades influenced the direction of the

movements, whatever may have been their primary cause.

A bridge of symmetrical construction and composed of uniform material, resting upon level and perfectly equal end supports would expand and contract, under equal exposure to the influence of temperature, at both ends alike, the movement taking place in both directions from the stationary center. But a very slight obstruction or impediment would suffice to cause inequality in the movement, and that inequality would increase with the magnitude of the impediment. As a practical proof of this observe the displacements in the horizontal spans of the bridge, which will be found generally of less extent than those in the inclined spans, evidently for the reason, that in addition to the unavoidable imperfections and inequalities in the bearing surfaces of the supports, the influence of the grades is producing its effects.

The total expansion in a 245 feet span, during extremes of local temperature would be about 2 inches; now if the movements had been altogether accumulative, progressing always in the same direction, without any compensating retrogression, the total movement during the fifteen years of the bridge's existence, due to temperature alone, would amount to 30 inches; but since the largest displacement observed in any of the spans, is only $2\frac{5}{16}$ inches, it seems reasonable to assume, that the movements must have been in a measure reciprocative, more pronounced perhaps in some spans than in others, but generally due to the influence of the grades and such other accidental causes, which produce movement on that support, which offers the least resistance.

If the influence of temperature alone were insufficient to account fully for the disturbance of the bridge trusses, it would be rather difficult to explain it from other evidence, but since the effect of temperature is much more than sufficient to cause the displacements, it certainly seems unprofitable to search for corroboration.

The expansion of cast-iron for each degree Farenheit is .000006167 per unit of length, and for 120 degrees = .00074 per unit of length.

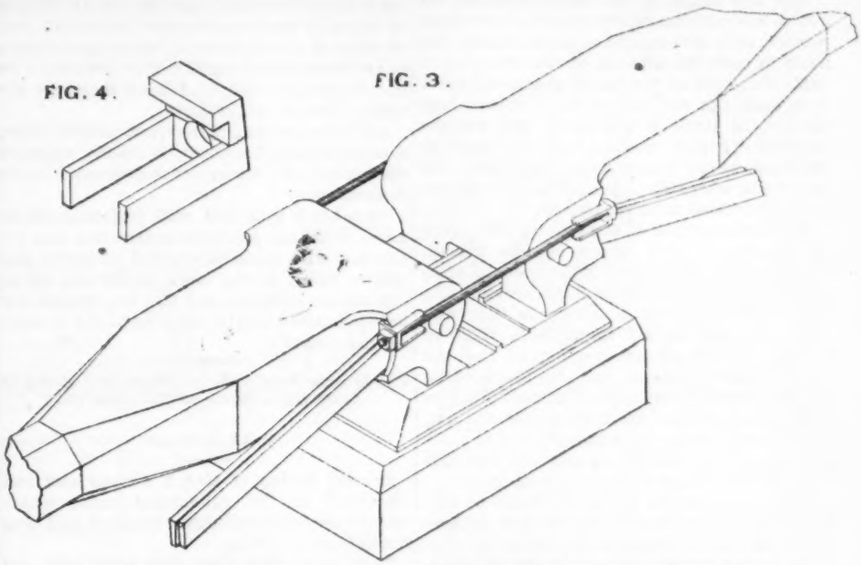
The modulus of elasticity of cast-iron (E) = 18,000,000 pounds. The force per square inch area of section exerted by the expansion is found from the proportion $F : E = .00074 : 1$ from which $F = 13320$ pounds per square inch.

Trautwine says the force of expansion in wrought-iron for 15° of temperature equals one ton per square inch, and the expansion of cast-iron is $\frac{1}{11}$ less than that of wrought-iron; this would give, for 120° a force of 16,000 pounds per square inch for wrought-iron, and 14,545 pounds for cast-iron.

Taking the first result, and applying it to the cross sectional area of one of the top chords of a 210 feet span (49.6 square inches) we have an expansive force of 660,672 pounds as the total maximum effect due to temperature.

Of course it cannot be presumed that this force would exert itself all at once; but only a very small part of it is quite sufficient to slide one of the bridge trusses upon its supports. The weight of one of the 210 feet spans is 388,000 pounds; one fourth of this amount, or 97,000 pounds would represent the load on one of the bearings of one truss; assuming the coefficient of friction of cast-iron on cast-iron at 0.15, the force required to move the chord horizontally upon one of its end supports would be but 14,450 pounds and, making correction for the inclined plane due to the grade, the actual force necessary to slide the truss would be represented by about $\frac{1}{50}$ part of the total force developed during the maximum range of expansion, corresponding nearly to a variation of $2\frac{1}{2}$ degrees of temperature; indeed it is clearly to be seen, that the expansion and contraction due to temperature is not only sufficient to move a span of bridge, but also its live load of locomotive and loaded cars covering the span from end to end. Indeed the force developed by the expansion or contraction of one span if applied all at once would be ample to move a dozen adjacent spans covered with engines and trains, provided the couplings were sufficiently strong to hold them together. That the couplings used in the attempt to arrest the movements were insufficient to overcome the friction of a single span, is demonstrated by their general failures.

FIG. 4. FIG. 3.



LOUISVILLE BRIDGE, CLAMP APPLIED TO PREVENT "CREEPING."

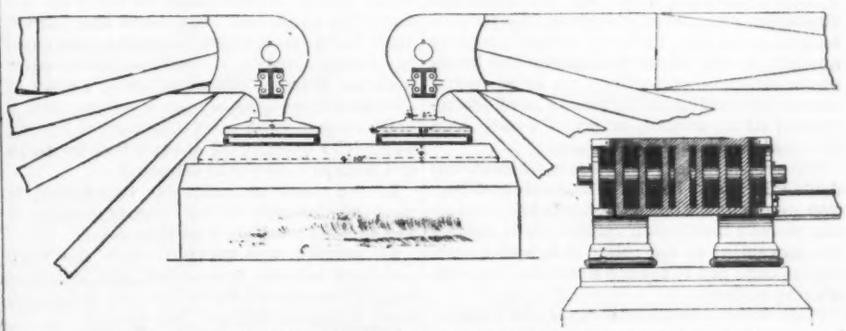


FIG. 5. LOUISVILLE BRIDGE; PROPOSED BED-PLATE WITH EXPANSION ROLLERS.

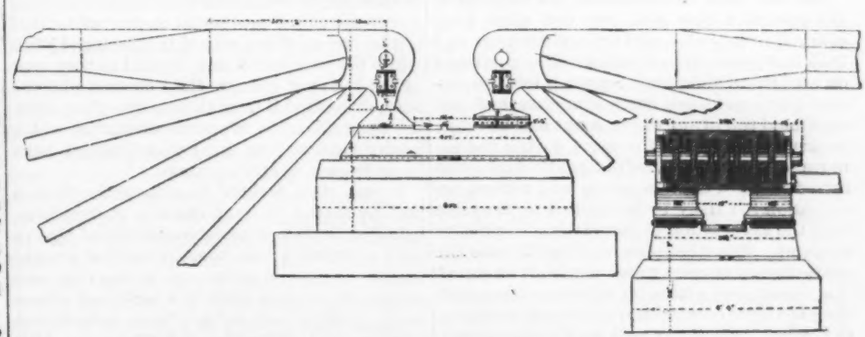


FIG. 6. LOUISVILLE BRIDGE; PROPOSED END BEARINGS.

The maximum resistance opposed to the tension of the couplings could in no case exceed the friction due to one loaded span, say 62,500 pounds for one truss. The failures occurred in all cases either by the breaking of the upper necks of the cast-iron lugs (see Fig. 4.) or by the rupture of the tie rods in the screw ends, just below the nuts. This may have been caused by shearing of the cast-iron lugs, or by a bending strain on their unsupported projecting part, or by the bending and twisting off of the screw end of the tie rod on account of the excessive strain upon that part of the nut, resting against the supported neck of the lugs.

The effective area of the neck of the cast iron lug, against shearing, after deducting the diameter of the bolt hole, which lies directly in the line of the shearing force is $2\frac{1}{4}$ square inches; allowing 27,000 pounds for the modulus of cast iron, the effective strength of the two lugs would be 128,250 pounds against a possible force of 62,500 pounds, which would seem to afford amply sufficient safety against failure by shearing.

If we consider the hook of the lug tightly fitting around the rib of the chord, and the force applied through the centre of the tie rod, the bending moment M will equal $P.\ x\frac{1}{2}$ inches

$$R = \frac{40{,}000\ x\ 2\frac{1}{2}''\ x\ 1.''}{6} = 15{,}833$$

and $P = \frac{15{,}833}{\frac{1}{2}} = 18.100$ pounds or for both clamps 36,200 pounds, when in fact a force nearly twice as large may have acted upon the clamp at any time.

The two wings of the lugs, intended for guides and bearing supports would be strained considerably at the point of juncture with the neck in case the bearing of the short hook against the rib of the chord should be more firm than the bearing of the longer wings against the sides of the chord; and rupture might easily have occurred from this cause at the neck, where in fact it most generally did occur, and where the lug is already weakened by the perforation for the tie rod.

Although the area of the two tie rods, each 1¼ diameter in the groove of the thread, amounting to 3¼ square inches, would seem quite sufficient to resist a direct tension like that above assumed as acting in this case, yet it is not at all improbable that on account of the uneven bearing of the nut against the outside of the lug, the bending moment, equal to that tension multiplied by the leverage of half the diameter of the nut, would break the tie rod at the edge of the nut just in such a manner, as some of the rods were actually found to have been broken.

If the causes above assigned should be still considered insufficient to explain the failures in the clamping arrangement, it would not require a very violent stretch of the imagination to assume, that the genius who resorted to these methods, also took the additional customary precaution to screw up the tie rods as long as his long handled wrench would go around, so that in all probability the initial strain was close up to the limit of elasticity, and a small additional force may have accomplished all the results, of which I have been trying above to explain the cause.

The proper remedy for these movements undoubtedly would be the introduction of friction rollers under one end of each truss reducing thereby the friction sufficiently to confine the movement to the roller end, and permit the opposite end to remain stationary upon its bearing surface.

Plans were in fact prepared for that purpose and partial arrangements were made to carry them into effect; see Figs. 5 and 6.

The first plan contemplated the removal of the present 9 inch cast iron bed plate from every alternate pier, and the substitution of 4 inch bed plates so as to admit roller carriages on top; this arrangement, while it left the present grade and track surface undisturbed, necessitated the lifting of the spans and the temporary supporting of the same during the removal of the present bed plates and during the introduction of the new plates and rollers, an operation too risky to be applied to 23 spans with the expectation of completing it without accident. The other plan provided for the introduction of friction roller carriages on top of the present bed plates on alternate piers and the placing of corresponding fixed blocking on the others; this plan would involve the bodily lifting of every span of the entire structure and compel a re-adjustment of the grade and track to meet the elevations at the shore ends, at the draw span and at the two channel spans. In addition to these difficulties it was found that the available surface on top of the new bed plates would be insufficient to admit roller carriages of the sizes required for safe bearing surfaces on the friction rollers.

These plans however were made under the apprehensions of actual danger to the bridge, based upon reports in regard to these movements, which were more alarming than reliable; but when I had taken a fuller view of the situation and investigated it in closer detail, I came to the conclusion that no remedies of any kind were necessary. The largest movement observed at any time brought the inner edge of one of the chord shoes close to the edge of the bed plate, from which position it has since receded 1½ inches. If it should be found at any time, that the chord shoes again approach the edge of the bed plates to a dangerous extent, it would be ample time and not a difficult task to pick up the span and place it back upon its normal support; but as nothing of this kind has been required during the past 15 years, it would certainly seem unnecessary to anticipate anything like it at present or in the immediate future. I have therefore advised to let the bridge alone.

As to the creeping of the track on this bridge, it is very insignificant, and is readily adjusted during extreme changes of temperature, at the draw span.

On a track well laid with judicious allowances at the rail joints for contraction and expansion, with angle bars bolted properly, and spiked firmly in the slots, there can be no cumulative creeping, and the movements due to temperature will be confined to the individual rail lengths.

The Means Employed in Repairing Belmont Submerged Main at Philadelphia.*

BY J.J. DE KINDER.

In the Spring of 1883, a serious leak was discoverd in the submerged main which crosses the Schuylkill River south of, and near the Columbia Bridge.

This main had been laid with ball and socket joints. Upon examination the diver found that, at a point about 150 feet from the east river bank, one of the bells had parted, allowing the male end to leave the bell, causing a large opening, through which the water from the Belmont Reservoir under a head of over 200 feet escaped in such a volume that a hollow was scoured out of the river bed directly under the opening of about 6 feet in depth and from 40 to 50 feet in diameter.

As the use of the main was imperative, to meet the demands of the summer months, it was decided to repair it without delay.

An attempt was made to force the male end back into the broken bell, the intention being to secure and strengthen the bell afterwards by means of heavy iron bands.

It was found, however, that the lead of the ball on the male end would not enter the bell; besides, any movement in this joint necessitated a corresponding movement in two additional joints, one on either side of the damaged joint, while the rust which had formed in that part of the bells not in immediate contact with the lead, prevented it from sliding into place without the application of enormous strains, which might have broken the two additional bells in preference to moving them.

It was then decided to remove the broken bell by means of light charges of dynamite, bringing the two successive lengths of pipe as near as possible into line, by moving several lengths of pipe on either side at one time and encase the broken part in a jacket or sleeve made of boiler iron, in two pieces, to be bolted together and strengthened furthermore with bands, etc., as shown in the plan.

This work was effectually accomplished; the hollow in the river bed under the main was filled in with stone and furnace slag, upon which willow mattresses were laid, weighted with more slag, thus making a good support for the main while preventing the possibility of scouring in the future.

It should be said in connection with this that the cause of the breakage explains itself, I think plausibly, in this way:

Some time before, a heavy ice gorge occurred at the Columbia bridge on the upstream side of the main in question, then followed a severe freshet, and the water found no other outlet just there than close along the river bed. The consequent rush of it scoured the lighter material from under the main (for at that point, owing to the direction given it by the presence of a small island above the bridge, the current is always swiftest and the depth of water greatest), the main for a length of some 40 feet lost its support, the bell end proved to be too weak to bear the weight unsupported, and parted, when no doubt the leak thus caused in the main added its quota to the scouring process.

The sleeve worked admirably so long as the main was used simply for a gravity supply, but before long it became necessary to use it in connection with a 20,000,000 gallons engine at the Spring Garden pumping station. Unfortunately the supply main from this engine, connecting with the submerged main, is but 30 inches, and consequently entirely too small. The sleeve then felt the impact of each successive stroke of the pumps, a series of hammer blows, as it were, which caused some of the bolts to break. Heavy iron clamps or dogs were added, one between each two bolts.

This proved effective for some time, but in December following the sleeve burst, tearing and twisting the sheet iron, and the main was once more useless. Fortunately the summer was over and the danger of a short supply of water avoided.

The next plan shows the manner in which the main was again repaired this summer and the means employed to make these repairs.

Before proceeding I might add that the river bed is mostly rock, making it impossible to drive piles. Again, to construct a loaded coffer-dam encircling the damaged joint would require it to be large enough to take in so much of the river bed as was filled in with slag and mattresses, otherwise it would be impossible to make a tight connection with the bottom; this, then, would require a coffer-dam of some 50 feet in diameter at least. The difficulty of making such a structure tight under these circumstances, and keeping it tight and in position in the event of heavy freshets, let alone the great cost, is readily understood.

From material already on hand (it having been previously used for other work), a bottomless box was built, its general dimension being:

31 feet long,
10 " wide,
25 " high,
} outside measurement,

long enough to take in over two lengths of pipe, wide enough to straddle the pipe and leave ample space on either side of it to work, and of sufficient height to reach clear above the surface level of a 6 feet freshet.

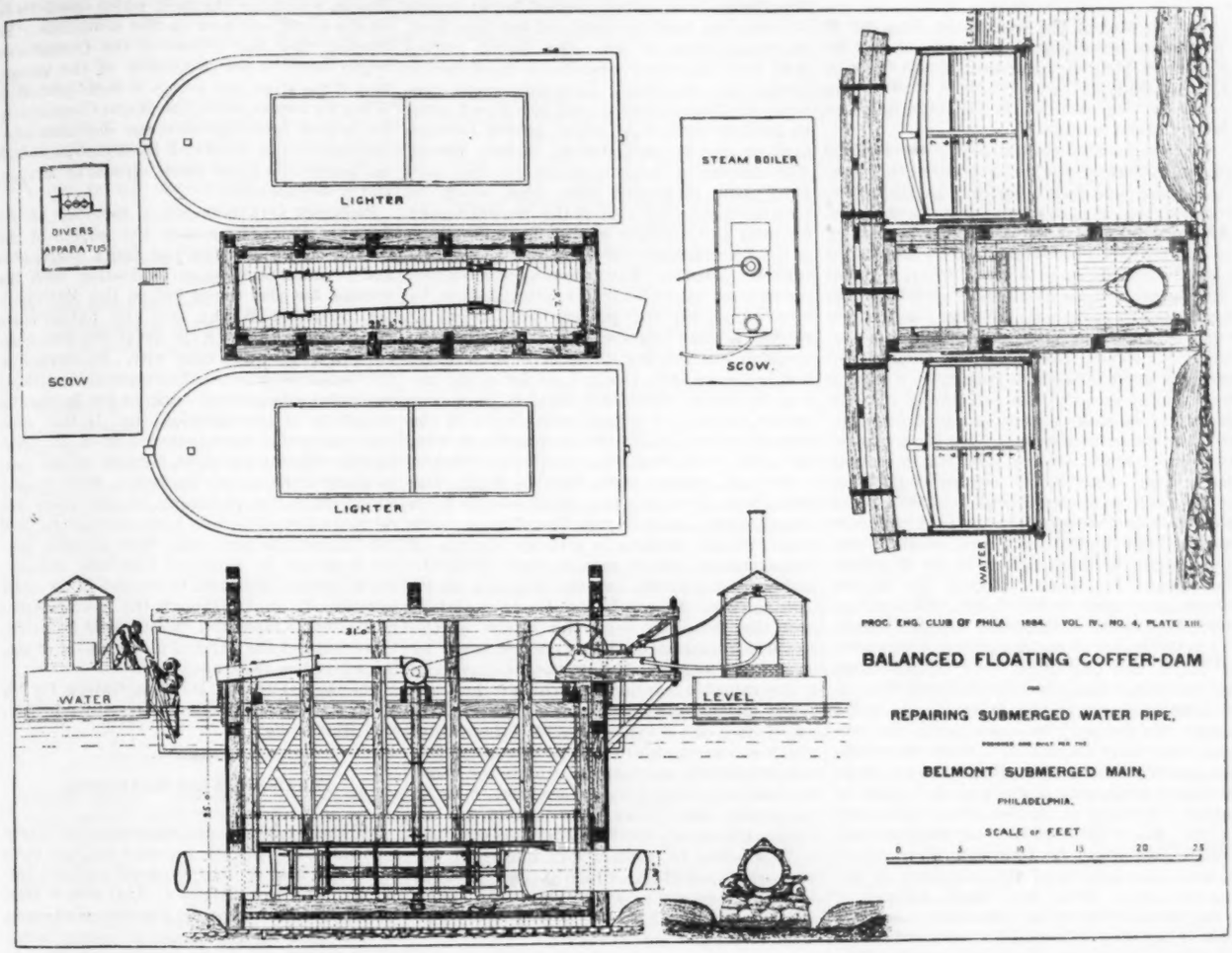
Since the plan is drawn to scale it is unnecessary to go into the details of construction and I will confine myself to a general outline of the work.

The box was built in three horizontal sections: the first one built on shore near the spot was sheathed vertically on the inside with 3-inch t. and g. spruce planks and horizontally on the outside. This outside planking was caulked and pitched. This section then was launched from ordinary ways and held suspended between two small lighters. The second section was then built upon and secured to it and the structure lowered until the upper sill was flush with the deck, then the third and last section was added, the dam floated over the damaged main into position, when it was finally lowered until it rested with the bottom sills on the river bed.

As shown in the plan, the ends of the lower section were left open for a height of seven feet, and only this section is sheathed on the inside. The first was done, not to ensure greater tightness, but simply to act as a continuous guide to a pair of loose sills, under and against which the loose floor was to rest.

By means of a diver the river bed, for a space about as large as required for the dam to rest on, had been levelled off, and when the dam finally rested on this fairly even surface —straddling the main—the floor and bulk heads for the ends of the lower section remained to be put in place. Using short, heav

*Read October 18th, 1884 before the Engineers Club of Philadelphia, and taken from the Club Proceedings, Vol. IV. No. 4.



timbers, chain slings and screws, the main was partly raised and the dam settled hard down on the bottom. This operation brought the underpart of the pipe high enough above the river bed, inside of the coffer-dam, to allow the floor to pass under it.

The sills marked *S* in the plan were connected at each end to vertical timber posts, *P*, let into the sill with a slack mortise, and secured each with one ¾ inch iron bolt, working freely in the hole. The sills, by means of these posts, were movable up and down, in guides which kept them snug up against the inside lining of the lower section.

By this arrangement, had the coffer-dam settled more at one end than the other, the sills could be adjusted to meet this angle, and thus bring the floor parallel with the underpart of the main anyhow.

The position of the sills, *S*, having been determined, the upright posts, *P*, were bolted to the corner posts of the coffer-dam, and the work of putting in the floor commenced.

This floor was made up of dry white pine pieces, 6 inches by 8 inches by 7 feet 5 inches, previously fitted together. Each piece was laid in position under the sills, *S S*, separately, and the whole work carried on as rapidly as possible, in order that the floor might swell tight.

Once the floor in place, the bulkheads were put in the ends of the low section. These bulkheads had also been built previously of two thicknesses of 3 inch t. and g. plank laid crossways, and finally canvas was battened over the ends and lashed with a masthoop around the projecting pipe. Additional shores were bolted against the inside of the uprights of the dam, and resting on the loose sills, *S S*, to prevent buckling, and shores placed on the floor between the same sills to keep them up snug against the lining.

With this completed, the question is how to keep the dam down in place while the water is pumped out.

Three beams were laid across the top of the dam, to which, by means of chains and hawsers, lighters were swung one on either side.

A small hatch, 8 inches square, was cut in the side of each lighter, also a hatch 18 inches square in either end of the dam. A batten, graduated in inches, was nailed to one of the piers of the Columbia Bridge near by, a similar one to the dam, and one to a post situated in the center of each lighter.

I then calculated the amount of water which each lighter was required to hold in order to counter-balance the buoyancy of the coffer-dam when empty. This water-line I made the zero mark on all four the battens.

If the river, during the operation, rose, I pumped more water into the lighters inch for inch, plus an allowance for the increasing buoyancy of the coffer-dam. When it fell I would lower the water level in the lighters accordingly, to prevent overstraining of the supporting beams. During heavy freshets I would fill the dam, open the hatches in the sides of the lighters and allow them to fill, thus preventing the possibility of their rising high enough to foul the supporting beams and raise the dam, while the presence of four hawsers, from the dam to the shore and bridge piers on the upstream side, made the risk under any circumstances very small.

An 8-inch Edwards cataract pump, with engine and boiler, completed the outfit.

Notwithstanding three freshets, two of which were uncommonly severe, the task was successfully accomplished. Of course, once started on the repairs of the main, with the dam empty, the work required pushing day and night without a break, while the height of the river surface needed continual watching.

When the repairs were completed the bulkheads were removed from the ends of the lower section, the loose floor ballasted with stone and sunk to the bottom, a bed composed of large stone and bags of hydraulic cement built upon it, firmly supporting the main, the chain slings supporting the main removed, and the coffer-dam floated away, after first removing the upper section and part of the middle section.

Adjusting Bridge Piers.

The stone piers under a bridge of the Wabash, St. Louis, and Pacific Railroad, across the Kankankee river, recently settled and were brought back to alignment in the following manner: The bed rock under the river was of varying degrees of hardness, and the piers were built upon wood platforms which rested upon a place prepared in the bed of the river merely by removing some of the loose material. In time, the rapid current removed enough of the gravel beneath these platforms to move the piers. The difficulty was remedied without interruption to traffic by divers, who removed the loose material between the bottom of each timber and the bed rock, by loosening it with bars and the scouring action of a jet of water; oak timbers were fastened upon the bed rock, and pairs of wedges, like printer's quoins inserted between the top of the oak timber and the bottom of the platform. The wedges were driven by a steel bar weighing 800 pounds, or about 700 pounds in the water, which was suspended by wires from the bridge above, and used as a battering ram against the wedges. The wedges were afterwards secured by bolts, which passed through wedges and timber; 100 wedges were used on each of the three piers, and the work was completed in ninety days by three divers and their attendant help.

Metropolitan Sewage.

At a meeting of the Society of Arts, Sir R. Rawlinson presiding in the absence of Sir Frederick Abel, the chairman of the Council, Captain Douglas Galton, C. B., F. R. S., read a paper on "Report of the Royal Commission on Metropolitan Sewage."

Captain Douglas Galton, at the outset of his paper, remarked that the disposal of the London sewage had been a burning question during the greater part of the last forty years. After giving, firstly, a brief historical summary of the various proceedings which had taken place in connection with the subject, he said that the present main-drainage system, which was stated to have cost 4,600,000*l.*, and which made no provision for deodorisation, was formerly opened in 1865. The criticisms of the referees upon Sir Joseph Bazalgette's scheme with reference to the limited provision made for carrying off the sewage had been fully justified by subsequent events. Looking back at the history of the sewage question, it seemed astonishing that good results could have emanated from the arrangement of 1885, which abolished uniformity of control over the main roads of the metropolis; and, while giving jurisdiction over main sewers to the Metropolitan Board of Works, placed the district sewers under the control of the different vestries, the control of the water supply remaining in the hands of eight different companies. If there was one thing more certain than another it was that a uniform control was especially necessary in the drainage and water supply of a district; the control over the sewerage especially should exist, from the reception into a public sewer of the sewage from the house-drain until it reached the point of outfall. Turning to the inquiry recently held by the Royal Commission on Metropolitan Sewage Discharge, he said that their report showed generally that the pollution of the Thames arose from the large volume of sewage thrown into it in a locality where the area of the river was small in comparison to the volume of sewage discharged into it. The volume of the dry weather sewage was now estimated at 23,000,000 cubic feet daily. The low water area of the river near the outfall was about 33,000 square feet, and this volume of sewage would fill a length of about 750 feet of the river at low water. At the present rate of increase of the metropolis its population would amount to 6,000,000 in 1901, and at a proportionate rate of increase, the sewage would reach nearly 35,000,000 cubic feet daily. Care in regulating the water-supply would materially reduce the dry-weather flow of sewage in London, as in Liverpool, Manchester, and other towns; but this seemed to be one of those questions which must wait until the government of London had been consolidated under one jurisdiction. The Commissioners were of opinion that the evils of the present sewage system called for a remedy with the least possible delay. At whatever time of the tide the sewage was now discharged, some of it might, under existing conditions, be carried up by the tidal oscillation alone into the heart of the metropolis, and even further. There was, in fact, a progressive increasing impurity of the river from Teddington downwards to the outfalls, and then a decreasing impurity to Gravesend, beyond which place the sewage was not perceptible. The Commission considered that the suspended solid matters in the sewage were the chief causes of nuisance, and that by precipitation the suspended matter might be almost entirely removed and the tendency to deposit largely lessened; but that the result of discharging an affluent alkalised by lime into the river at the present outfalls was problematical; they thought, however, that lime would probably be as good as any other chemical for purposes of precipitation. They concluded that some process of deposition or precipitation should be applied to the London sewage at the present outfalls; the sludge being either applied to the raising of low-lying land, or burnt, or dug into land, or carried away to sea. The liquid portion was, as a temporary measure, to be allowed to escape into the river. As a permanent measure, the Commissioners said this liquid must be further purified by being passed through land, or else be carried down to Hole Haven. The amount of land necessary for this purpose, after treatment with lime, would be 6,000 acres, and the cost of the capital outlay for land and requisite works, upon the basis of the Birmingham expenditure, would apparently be 1,500,000*l.* The Commission estimated the annual expenditure for precipitation by lime alone, on the present population, at 200,000*l.* a year. Proceeding to consider the question whether the limits of concentration had not been fully reached, so far as the metropolis and its subsidiary districts were concerned, he asked if sewage from places in the Thames valley, above the metropolis, or from the valley of the Lea, was required to be taken to the sea, where were they to stop? The difficulties of the sewage question arose from concentration, and it was therefore a much more rational solution to give up the idea of concentration, and to require each district to make arrangements for the disposal of its own sewage. In conclusion, Captain Galton said the importance of the report of the Royal Commission consisted not so much in what was recommended for the metropolis as in the valuable information which it had collected on the present state of the general questions of sewage-disposal—information which was applicable to the whole country. The comprehensive manner in which the subject had been treated was of especial value at the present time, because the country was becoming too closely built over for this question to be allowed to remain any longer in the *laissez-faire* conditions which it had hitherto occupied, if regard was to be had to the purity of the air, the purity of the soil, or the purity of the rivers and water-courses.

The chairman said the report of the Royal Commission on metropoliton sewage was, in his judgement, as able a document on the question with which it dealt as the public had had presented to it up to the present time.

A discussion ensued, in the course of which Colonel Ewart, a member of the Commission, said one of the leading differences in the finding of the Commission from that of the referees was that, instead of the sewage being taken down upon both sides of the river, if it were so taken down according to the alternative mentioned in the report, it should be taken down upon one side only. Many considerations were involved in this matter, one of the most important of which was that of expense The expense of carrying a tunnel under the river to unite the sewage of one side with that on the other had to be considered against the cost of carrying a separate sewer down on the south as well as the north side, and it would be seen by reference to the evidence abduced before the Commission that there were very strong reasons which induced them to recommend that the sewage should be combined by carrying it under the river and wholly to one point. The Commission rather adhered to principles than entered into details.

Sir F. Nicholson, of the Thames Conservancy Commission, expressed a hope that the result of the report might be that some measures would be adopted, and without any great delay, to prevent what was an undoubted fact, although it might be going on so slowly as not to be apparent to every one—namely, that if the pouring of the semi-solid sewage into the river was continued unchecked the navigation of the Thames must eventually suffer. It was quite true that as yet the deposits had not done any absolute harm to the navigation, although there was no doubt they had altered the channel entirely in Halfway Reach, where the channel, which used to be on the north, was now on the south side. He trusted that the report of the Commission might result in the protection of the navigation of the river, and secure it from pollution. When he accompanied the Royal Commissioners in their investigations one day last summer the river at Woolwich Dockyard presented the aspect of a great black stream of sewage, and of sewage only.

Professor De Chaumont, a member of the Royal Commission, said the object of the Commission was not only to find a reasonable and permanent method of dealing with the sewage, but also to put before the Metropolitan Board of Works and the public some means of dealing with the great evil which existed in a rapid and easy way. It seemed to the Commission perfectly practicable, without any great extension of work, to put in practice a system of precipitation, and if that were done and solids were removed from the sewage the effluent might, at present at any rate, be allowed to run into the river. With respect to the utilization of sewage, he said there was no doubt that if they took the market value of the ammonia poured daily into London sewers it would be equal to 1,250,000*l.* sterling; but it was not desirable to expend 2*l.* in order to realize 1l., and, although the sewage might be applied to land, and crops might be grown, there was not the ghost of a chance of realizing a profit on the transaction.

Thanks to Captain Douglas Galton for his paper terminated the meeting.—*London Sanitary World.*

Disinfectants and the Cholera.

"While wishing every success to all lawful scientific experiments, we must not lose sight of the fact that cholera, typhoid, and all kinds of plagues, are diseases that either arise directly from overcrowding in cities and camps or that find in the results of overcrowding the awful hot-bed, the deadly swamps in which they may increase and multiply."

"Cholera," said Captain Horton musingly, "seems to me to be a disease of so terribly infectious a character, that whatever the municipal authorities may do to stay the progress of the epidemic, the individual himself who lives where it is rampant is powerless to defend himself."

"Here, again, I think you err. It cannot be too well known that the choleraic germ—and the same may be said for other plague sporules, typhoid included—cannot exist where there is abundance of pure air. The dilution, medical men tell us, of poisons of this kind renders them ine I do not think it is dilution that effects this. In my opinion, just as there is a deadly serpent—an ophiophagous reptile—which eats deadly snakes, so there is a gaseous poison that destroys plague poisons, and that is oxygen gas, which in its diluted form we breathe, and cannot live without."

"Then," said Captain Horton, "if I understand you aright, you would defend the Fortress of Life from the attacks of invisible enemies by means of disinfection."

"Call it rather by perfect purification of all our surroundings, and the maintenance of complete and through cleanliness. I do not quite like the word 'disinfectants' for many reasons. A disinfectant is never needed where there is pure air and wholesomeness. You *may* destroy dangerous emanations and foulness in the air by the use of disinfectants, but the best plan is to remove the cause. A person by constantly using disinfectants might manage to live—hardly in health, though—in a room permeated by the vapors from a cesspool. Removal of the latter would be the wiser way of going to work."

"Again, a disinfectant may be itself a poisoner of the air, and often it is a mere

make-believe. You smell the odor of the chemical, whether it be chlorine, or carbolic, or anything else, and you say to yourself, "Why, this disinfectant is doing its work nicely. No impurity can exist in the air where this is."

"So, I say, do not trust altogether to disinfection: it is a good servant, but wants careful guidance and watching, and must not have more work to do than it can accomplish."—*A Family Doctor, in Cassell's Family Magazine for April.*

The Theory and Calculation of Earthwork Slopes.*

Written for ENGINEERING NEWS.

BY MANSFIELD MERRIMAN, M. AM. SOC. C. E.
Prof. of Civil Engineering at Lehigh University.

Continued from Page 174.

6. THE COEFFICIENT OF COHESION. The value of c for homogeneous earth may be found as follows: Dig in the ground several trenches of considerable length compared with their width and of different depths. After a few days it will be observed that all those over a certain depth have caved along some plane such as $B\,M$ in Fig. 2. Let H be the value of this

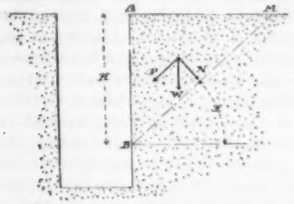


FIG. 2.

certain depth. Let w be the weight of a cubic unit of earth and Φ its angle of repose when devoid of cohesion. Then the coefficient of cohesion of the earth may be computed from the expression,

$$c = \tfrac{1}{4}\, H\, w \tan (45 - \tfrac{1}{2}\Phi)$$

N. P. This formula we will now demonstrate.

Let the plane $B\,M$ in the figure make an angle x with the horizontal. The prism $B\,A\,M$, whose length perpendicular to the drawing will be taken as unity, tends to slide down the plane. Let W be the weight of this prism, and P and N its components parallel and normal to $B\,M$. P tends to cause motion down the plane and this is resisted by the combined forces of friction and cohesion, acting in the plane. The force of friction is $f\,N$ and that of cohesion is $c\,l$, if l be the length, or area, of $B\,M$. At the moment of rupture

$$P = f\,N + c\,l$$

from which the value of c is

$$c = \frac{P - f\,N}{l} \qquad (4)$$

In order to determine the angle x consider that the equations just written are for the plane of rupture and that for any other plane P is less than $f\,N + c\,l$, or $\dfrac{P - f\,N}{l}$ is less than c.

The value of x for the plane of rupture is hence that which renders

$$\frac{P - f\,N}{l} = \text{a maximum.} \qquad (5)$$

Equation (5) will determine the value of x and then c will be found from (4).

To do this insert first for P its value $W \sin x$, for N its value $W \cos x$, and for f its value $\tan \varphi$. Then (5) becomes

$$\frac{W}{l}(\sin x - \tan \varphi \cos x) = \text{a maximum.}$$

This may be written

$$\frac{W \sin (x - \varphi)}{l \cos \varphi} = \text{a maximum} \qquad (5^1)$$

Next express W in terms of H and x and the weight of a unit of volume of earth w. Thus

$$W = \tfrac{1}{2}\, H\, l\, w \sin (90° - x)$$

and then (5^1) becomes

$$\frac{H\, w \sin (90 - x) \sin (x - \varphi)}{2 \cos \varphi} = \text{a maximum.}$$

This expression is a maximum when the two variable factors are equal, or when

$$90 - x = x - \varphi$$

Thus the value of x for the plane of rupture is

$$x = 45° + \tfrac{1}{2}\varphi \qquad (6)$$

Now to find c, insert in (4) the values of P, N, and f in terms of x, and it becomes

$$c = \frac{H\, w \sin (90 - x) \sin (x - \varphi)}{2 \cos \varphi}$$

which by virtue of (6) reduces to

$$c = \frac{H\, w \sin^2 (45 - \tfrac{1}{2}\varphi)}{2 \cos \varphi}$$

Since $\sin^2 (45 - \frac{1}{2}\varphi)$ equals $\frac{1}{2}(1 - \sin \varphi)$ this value becomes

$$c = \frac{H\, w (1 - \sin \varphi)}{4 \cos \varphi} \qquad (7)$$

This is readily reduced to the form

$$c = \tfrac{1}{4}\, H\, w \tan (45° - \tfrac{1}{2}\varphi) \qquad (7^1)$$

which is the formula that was to be demonstrated.

When the numerical value of c is to be found (7^1) is the most convenient formula, but in discussion (7) is often preferable, as will be seen later. For earth weighing 100 pounds per cubic foot and whose angle of natural slope is 30 degrees the value of c becomes $14.4\,H$. If the vertical rupturing depth H is one foot, c is 14.4 pounds per square foot, but if H is ten feet then c is 144 pounds per square foot.

TO BE CONTINUED.

WITH all her other troubles— in Egypt, and Ireland, and Asia—old England has also been passing through a serious agricultural crisis, in which the ancient proverbial expression, "as good as wheat," lost its force for the price of that commodity touched the lowest point it has reached in the life of this generation. What brought on the crisis, what were its effects, and what remedies have been proposed, are questions that concern the American almost as much as the Englishman, whether he be a producer or a consumer of wheat; and they are very ably and clearly discussed in an article by William E. Bear, editor of the Mark Lane Express, in the *North American Review* for April. In the same number, Charles Dudley Warner presents an interesting "Study of Prison Management," while Robert Buchanan, the English poet, discusses "Free Thought in America." T. V. Powderly "The Army of the Discontented," and Prof. Hunt, "How to Reform English Spelling." The other articles are: "The Laws Delay," by Chief-Justice Thomas F. Hargis," and "Characteristics of Persian Poetry," by A. R. Spofford. But what will probably attract the most immediate attention in this number is the new department of "Comments," consisting of brief criticisms of articles that have appeared in the Review. Murat Halstead's political article in the March number is here discussed by three writers—a Democrat, a straight Republican, and an Independent Republican. Richard H. Stoddard comments with a good deal of feeling on Max Müller's "Buddhist Charity," and other correspondents take this pleasant opportunity to offer a single thought where an extended article would, herhaps, find neither room nor readers.

a MANY believe the art of making artificial stones to be prehistoric, and that the Pyramids were built of artificial blocks manufactured from the sands of the surrounding plain. In modern times a Frenchman named Coignet, made the artificial stone that comprises a section three miles in length of the Vanne aqueduct for supplying water to the city of Paris, and that used in the construction of the light-house at Port Said, Egypt. The latter is 180 feet high, without joints, and rests upon a monolithic block of beton containing nearly 400 cubic yards.

FROM reports just issued it is seen that Boston is not behind Western cities in rapid growth of expenses in running her city government and in rates and amounts of taxes. In 1822 her rate per thousand was $7.30, and the amount of taxes raised $167,583. In 1842 the figures stood $5.70 and $637,779, while in 1884 they had bounded up to a thousand rate of $17 and the amount of taxes raised to $11,286,369.

SELECTED MISCELLANY.

THE Mansion House, bank and Royal Exchange in "The City," London, form a small triangle through which it is not uncommon for 64,000 vehicles and 125,000 pedestrians to pass daily. The tide of travel there has become so great that a subway or tunnel is being projected to relieve it.

THE temperature of the mines on the Comstock vein is exceptionally high. At depths of 1500 feet and 2000 feet, the thermometer placed in a fresh-drilled hole will show 130°. Very large bodies of water have run for years at 155°, and smaller bodies at 170°. The temperature is kept down 110° by forcing in fresh air cooled over ice.

AT Wilkesbarre there has recently been manufactured a wire rope one mile, 500 feet in length, and two and a half inches in diameter. Its total weight is thirty-two tons, and its tensile weight has been tested up to ninety-two tons. It is made of six strands of wire rope, each a little over three-fourths of an inch thick, and composed of nineteen wires. These six strands are wound around a hemp rope, which, though not supposed to add strength to the cable, gives it flexibility. The iron used is all of the best Swedish variety. Such a cable is estimated to be capable of hauling up the planes 8,000,000 or 9,000,000 tons of coal before being worn out. It cost $4,000.

"TERNE" plate can easily be distinguished from properly tinned sheet iron by the sense of touch when handled by experienced persons, unless the terne coating contains an unusually small proportion of lead. Fordoz's test may, however, be depended upon as final. Clean the surface of the suspected plate, using a little ammonia to remove every trace of grease, and dry thoroughly in a gentle heat, after applying a drop of nitric acid. Let a drop of the officinal solution of iodite of potassium fall on the place where the nitric acid was laid. A yellow spot will appear if the least lead is present. This test, as has been shown, is a good one for examining the quality of enamels of cooking vessels.

THE last act in the Fontaine locomotive episode occurred this month at Detroit. This locomotive was the invention of Engene Fontaine, of Detroit, and wonderful results were promised for it. The central idea was the introduction of two friction-wheels above the driving-wheels. By the contact of the upper wheel with the lower wheel a greater number of revolutions per minute could be obtained, and hence a greater speed would result. A company was formed with $1,000,000 nominal capital. Two engines were built at an expense of $25,000, but they proved a failure. Altogether the company paid out $47,000 and received $2,700 in return. This was received on the day named from the Lake Erie and Western Railway, which bought the engines and will rebuild them as ordinary locomotives.

SOME timber is more durable in wet ground or immersed in water; such as elm, beech, alder; while others, such as ash, oak and fir, are more durable in dry situations. The increase in strength due to seasoning of different woods is given as follows: White pine, 9 per cent; elm, 12.3 per cent; oak, 26.6 per cent; ash, 44.7 per cent; beech, 61.9 The comparative value of different woods, showing their crushing strength and stiffness, is: Teak, 6,555; English oak, 4,074; ash, 3,573; elm, 3,469; beech, 3,079; mahogany, 2,571; spruce, 2,522; yellow pine, 2,193; sycamore, 1,833; cedar, 700. Regarding the relative degrees of hardness, shell-bark hickory stands highest, calling that 100; white oak is 84; white ash, 77; dogwood, 75; scrub oak, 73; white hazel, 72; apple, 70; red oak, 69; beech, 65; black walnut, 65; yellow oak, 60; white elm, 58; hard maple, 56, wild cedar, 55; yellow pine, 54; chestnut, 52; white pine, 30.

HEIGHT OF MONUMENTS.—A comparison of the height of the Washington Monument with some of the highest structures and memorials of the new and old worlds will be instructive. The figures in feet are:

The Washington Memorial	555
Cathedral at Cologne (towers)	511
The Great Pyramid	486
Cathedral at Strasbourg (spire)	468
Cathedral at Amiens (central spire)	422
St. Peter's, at Rome (to top of dome)	405
St. Paul's Cathedral (dome)	365
Cathedral at Milan	355
The Bartholdi Statue	300
Capitol at Washington (dome and statue)	287
Lincoln Cathedral (tower)	300
Brooklyn Bridge (towers)	287
Trinity Church (steeple)	284
Statue of Liberty	220
Philadelphia Cathedral (dome)	210
London Monument	202
Nankin Porcelain Tower	200
Washington Monument, Baltimore	196
Arc de Triomphe, Paris	160
Colonne Vendome, Paris	144
Trajan's Pillar, Rome	130
Pompey's Pillar, Alexandria	124
"Germania" Statue	110
St. Charles Borromeo	106
Colossus of Rhodes	105
"Bavaria" Statue	90
Statue of Memnon	65

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CORRESPONDENTS frequently remind us that while we are constantly publishing the incorporation of new railroads we rarely give the name of the Chief Engineer among the list of officers.

We would remind this class of our readers, that we make a point of noting the Chief Engineer whenever it is at all possible; but the bulk of these railway items are condensed clippings from a mass of newspapers received from all parts of the country. We can only publish what we find. Many of these enterprises are just being launched; exist only on paper and are in a very embryonic state indeed.

We need not remind our readers that a Chief Engineer, or in fact any engineer at all, is not always a first requisite with a certain class of modern railway promoters. With these men, a plausible pretext for a line from x to y is sufficient grounds upon which to "organize" and issue certain chromos called bonds and stock; a location taken from the county map and a guess at the probable cost, an estimate more or less shrewd as the guesser has experience, is the original stock in trade. An engineer is employed later, when a sufficient number of investors have been induced to put some cash into the business. Considerable engineering is required in the initial launch of a railway, but it is at times more "crooked" than "civil."

This is why we can not always give the pedigree and post-office address of the Chief Engineer of newly organized railways.

WITH the April *Century* Magazine comes an excellent map of the Soudan, enlarged from the smaller map of the March issue for the new edition. It is an interesting bit of geography just at this time, and is very full in its detail of sought-after localities. The April *Century* is verily a "war number;" containing the "Opening of the lower Mississippi," by Admiral Porter; New Orleans before the capture," by George W. Cable, and an account by Commander Albert Kautz of the fire on the flag ship of Admiral Farragut.

IN the Report of the Examiners of Section XXVII of the late International Electrical Exhibition at Philadelphia, the following are noted as among the "applications of electricity to warfare:" Search and Focusing lights, including the Brush, U. S. Electric Light Co., the Thompson and the Mangin Projectors; the McEvoy Torpedo Detector, and Chronographs for determining the velocity of projectiles.

Irrigation in Colorado.

The report of E. S. Nettleton, State Engineer of Colorado, contains an amount of interesting matter on the subject of land irrigation, investigation in this direction being one of the chief duties of the State Engineer.

The report commences with a description of the topographical and meteorological features of Colorado, and the facilities for, and progress of, irrigation in that State. The bulk of the farming lands lie at an average elevation of 5000 feet above the sea, though these lands range from 3,500 to 7,500 feet in altitude. Nearly one half of the State lies in the plains, or the one-timed so-called "Great American Desert." This is only a desert when deprived of water; the soil being generally productive when irrigated, and the amount of land capable of cultivation is only limited by the water supply which can be brought to it from the mountain streams flowing eastwardly, which combine to form the South Platte and Arkansas Rivers. The character of tributaries to the rivers named is, deep floods after heavy rainfalls, subsiding to muddy streams during the wet season, and dried up entirely for nine months in the year. From the great majority of these streams no irrigation is possible except by impounding the flood waters. The divide between the Arkansas and the South Platte Rivers is known as the Colorado divide, and its summit is from 1000 to 2000 feet above the rivers, the distance between the rivers ranging from 120 to 210 miles. In this district all the water available, even with the flood waters impounded, would irrigate but a fraction of the whole area; and the cultivation will probably be confined to the foot-hills.

In the Valley of the Rio Grande, the irrigated lands lie in and around San Luis Park, and in the narrow tributary valleys. On the western slope of the State, there is an excess of water but little irrigable land.

Mr. Nettleton says: that although it is generally conceded that the rainfall and humidity of the States west of, and contiguous to, the Mississippi, has increased with the settlement and operations of husbandry, all attempts have failed to show, *by record*, that a similar increase has occurred with the settlement of the States and Territories of the Rocky Mountain region. On the contrary, in the Salt Lake district, the oldest settlement in the mountains, the records kept at Fort Douglas, from 1863 to 1874 by the garrison, and since by the Signal Service, show that from 1864 to 1868 inclusive the mean annual precipitation was 19.22 inches; while in the five years, 1877-1881, the annual mean is only 15.41 inches; the annual mean for the whole period was 18.92 inches. As the records of each of these groups of years was kept in a different locality, it is well to state that Major Powell, in comparing the average precipitation at Fort Douglas and Salt Lake, shows that the greater rainfall is at the latter place. It would thus appear that the advantage of locality was in favor of the years 1877-81. The report includes tables of rainfall etc., at Denver and Cheyenne from 1872 to 1884 inclusive. At Denver, the annual rainfall, mean of the fifteen years, is 15 inches; actual barometer, 24.7; temperature, 49.2°; prevailing wind, south, and humidity, 48.4, all for the period 1872-84. At Cheyenne, Wyoming, the mean annual record of rainfall for the fifteen years is 10.34 inches. At Pike's Peak, from 1874 to 1881, the mean annual rainfall for nine years is 34.41 inches.

Mr. Nettleton is satisfied from these records that the rainfall is *not* increasing in the Rocky Mountain districts; but he is also satisfied, from personal investigation, that the *Autumn* discharge of the streams within the irrigated district is greater than it was fourteen years ago. This, in accordance with the deductions of Powell and Gilbert at Salt Lake, is due to the action of the white settlers in removing obstacles to rapid drainage in the settled districts.

The fact that this country is only settled in isolated strips and does not present a solid front of occupation, must also be considered in comparing its rainfall with States further east.

If all the "farm lands" of Colorado were assumed to be really farmed land, it would only amount to six per cent of the total area of the State.

Prior to 1860, the practice of irrigation was confined to a few scattered Mexican and American settlements, mainly on the bottom lands. In 1859, Horace Greeley, in his tour through Colorado, was impressed with the belief that the higher lands were best adapted to cultivation if they could be irrigated, and on his return to New York he laid the subject before the late N. C. Meeker, the agricultural editor of the *Tribune*. A colony was proposed through his paper in 1869 and in 1870 the scheme was brought to a successful issue by the formation of the Union Colony which settled in the valley of the Cache la Poudre, and founded the town of Greeley. In the same year this colony started the first canal in the State for the conveyance of water to the table-lands; and their example has lead to the present system of land irrigation.

While it is impossible to give exact figures, the best estimate of the area of farm lands puts it at 3,834,619 acres in 1884. Assuming that three-tenths of this is irrigated land, this would amount to 1,150,386 acres in 1884.

The report follows with a tabular comparison of the progress of construction of canals and ditches with the demands for public lands, and a detailed description of the 26 water districts of the State.

In gauging the stream of the state. Mr. Nettleton first made use of the Fteley meter for obtaining the current velocity, but finding that this instrument was entirely too delicate for the rough torrents filled with drift of all kinds, he designed an instrument better suited to this work. This machine he calls the Colorado Current Meter; it acts on the same general principle as the "anemometer," or wind-gauge, the principal change being in the shape and number of the cups. It has five cups revolving horizontally on an axle, having bearings at the open end of a ⊏ shaped metal frame, the cups passing between the sides of the ⊏. On the upper arm of the frame is affixed a set of counting gears so arranged that they can be instantly thrown into or out of connection with the vanes by means of a spring and a cord passing up the metal rod, by which the instrument is held in the desired position in the water. The shape of the cups is such that floating weed, etc., will not be retained longer than about ⅛th of a revolution.

These meters are each rated separately by moving them in still water at known velocities. To measure the current velocity at any point the meter is held in it for say 100 seconds, and the number of revolutions recorded; this operation is repeated at various points on the cross-section and the mean velocity thus determined, a gauging at several depths being taken when the depth of the flume or stream is considerable.

The duty of water in Colorado is yet impossible of definition. The many factors, of soil, "lay" of the land, subsoil, kind of crop, skill of the irrigator, climatic conditions, etc., make it doubtful if any duty can even be

precisely established. Major Powell, in his "Lands of the Arid Region," says, "one second foot of water will irrigate 80 to 100 acres in Utah," but, "many of the farmers will not admit that so great a tract can be cultivated by this unit." Col. Baird Smith, in his report on Italian Irrigation, states that "the general average area irrigated by each cubic foot of water 'per second,' throughout Lombardy, amounts to 70.2 acres."

A very practical method of increasing the general duty of water in Colorado is to convince the irrigator of the truth of the fact (established by experience) that a more sparing use of water, even at an increase of cost in its application, *will pay*, both in quantity and quality of crops; too profuse watering of the land tends to make it cold and washes out or drives away the fertilizing elements. As an example of the benefit to be derived by a small increase of the duty of water, the following computation is made: In the Cache la Poudre valley, the average duty of water is about 50 acres per foot-second. If this duty were raised to 65 acres, and if the value of a second-foot of water in perpetuity be estimated as worth $750,000, the saving on the 2,500 cubic feet per second (estimated as the amount used) will be worth $552,500. The result of estimates made by the organized canal companies and based on the experience of the older irrigators, range from 50 to 55 acres per cubic foot per second; this is the first really practical estimate of the duty of water in irrigation in Colorado.

An appendix to the report contains the names of ditches or canals open, the date, cubic feet of water appropriated to each priority, summation of appropriations and the cubic feet per second previously appropriated; also field notes of gauging, and a diagram of discharge, of the Cache la Poudre River.

Draftsman's Adjustable Curve Ruler.

The drawing implement here figured is designed to supplement the well known French Curves, and is recommended as a most excellent and handy tool wherever irregular curves or shapes are to be drawn.

The working edge is flexible but with a certain amount of spring to it which causes it to always assume a uniform and perfect curve. It can be instantly adjusted to any form and will retain the shape given it, the retaining power being a small bar of pure, drawn lead, covered by sleeves and sliding between two ribbons of tempered steel.

The working edge is cylindrical in cross-section so that, by slightly inclining the pen, two or more parallel lines can be drawn without moving the ruler. The whole length of the ruler is 14½ inches with a working edge of 10 inches. Price and further information can be obtained of G. S. Woolman, 116 Fulton St. New York.

Pneumatic Transmission between London and Paris.

Translated for ENGINEERING NEWS.

M. Berlier, inventor of a system of pneumatic transmission, proposes to lay between London and Paris two pneumatic tubes, one to transmit and the other to return telegrams, letters or pamphlets; the package to be posted under fixed conditions of volume up to 5 kilos in weight for each transmission.

Notwithstanding the difficulties of construction and operation, due to the length of the line and its passage under the Straits of Dover, the inventor does not consider these insurmountable.

The system proposed by him is outlined as follows: On the land the line will follow one of the railways, passing from Paris to London by way of Clermont, Amiens, St. Valery, Boulougne, Calais and Dover. Its length will be about 500 kilometers (310 miles).

The deepest point in the sea between Calais and Dover is 56.70m (186 feet); the highest point on the Northern R. R., between Paris and Calais, is 121.32m (397.8 feet); this gives 178.02m (583.8 feet) as the extreme difference of elevation to be overcome. The bed of the sea at the crossing point is made up of a series of easy and regular slopes.

The construction of the line will present no difficulty that can not be overcome by modern engineering science. The tubes will be formed of cast-iron, 0.30m (11¾ inches) in diameter and 4m (13 1/10 feet) long; they will be connected by a special joint of rubber, giving the line a certain degree of flexibility, great elasticity, and at the same time an absolutely water-tight, strong joint.

The transmitter would be a case made of iron wire enveloped by a web of mountain flax (*amiante*) secured by a metallic chain. This flax wrapping would in turn be surrounded by a kind of a brush made of metallic filaments, which would permit the compressed air to envelope the transmitter, to a slight degree, and by cooling it to counteract the heat produced by friction. The inventor would admit a transmitter weighing about 13 pounds, and carrying a load of despatches not exceeding 11 pounds in weight. The time of transmission from Paris to London would be one hour, and the transmitters would be started every ten minutes. In reality then the train would be a piston moved by compressed air without any detention in the entire length of the tube; the speed will approximate 139m (450 feet) per second.

M. Berlier estimates the resistances to be overcome as being of three kinds:

1st. Friction of the train in the conduit.

2nd. Friction of the air in the tube.

3rd. The work of raising the trains over the elevations in the line.

In taking 0.70 as the coefficient of friction, in the first case, that being the figure given for a leather packed piston working in cast-iron—which is too high for the flax packing used—the frictional value for a train weighing 10 kilos (22 pounds) would be; $10 \times 0.70 = 7$ kilos, and for a course of 500 kilometres in an hour:

$$F = \frac{500{,}000 \times 7}{3600} = 972 \text{ kilogrammetres}$$

(7027.5 foot pounds) per second, or about 14 horse-power.

In regard to the friction of the air in the tube, experience does not yet permit any exact calculation. But, taking into account the considerable diameter of the tube and the result of experiments made at the Mont Cenis tunnel, M. Belier believes that the loss of power from this cause will not exceed 14 horse-power.

Neglecting any gain from the down grade portions of the line and considering the ascents only, the sum of these ascents is valued at 682.7m (1556.55 feet). These up-gradients are distributed over a length of 263 kilometres (163 miles) as follows:

From Paris to Calais	313	metres
From Calais to Dover	56.70	"
From Dover to London	313	"
	682.70	metres.

These figures have been established by M. Belier by taking for the ascents in the English lines the same figures as those known for the French railways, though the developement of the latter line is double the English. The total time required by this line would be 1892 seconds. The work necessary to overcome these elevations would then be:

$$\frac{682 \times 10}{1892} = 3.6 \text{ kilogrammetres (26 ft. pounds).}$$

So that a total power of 28 to 30 horse-power would be sufficient to produce the displacement of the train and the air in the tube.

To fill in one hour a conduit 0.30m in diameter and 500 m in length, would require a volume of air equal to 35,325 cubic metres (1,246,972 cubic feet), or about 9.810 cubic m (346.3 cubic feet) per second.

The next question is, the pressure which it is necessary to give this air to do the work proposed. The section of the conduit is 706 square centimetres (109 4/10 square inches). The velocity is 139m (456 feet) per second, and the work, to obtain 30 horse-power, would be 2,250 kilogrammetres (16,267 foot pounds). After applying a coefficient of 0.50 for the practical value of P, M. Belier concludes that by furnishing $9^{m3}.810$ of air per second under a pressure of 0.0458 kilos (.65 pounds per square inch) he should be able to send from Paris to London, in one hour, a train weighing 10 kilogrammes (22 pounds) and presenting a section 700 square centimetres.

Supposing that trains would be started every ten minutes, there would be six trains at one time in the conduit; and the interval between any two consecutive trains would be 83,000m (272,240 feet), and the air which fills this interval would form a species of bracing between the two trains. Owing to the loss by friction the initial pressure must be augmented in proportion to the number of trains, and the inventor concludes that a normal pressure of 2 kilogrammes (28.4 pounds to the square inch) would be sufficient to meet a demand of one train in every three minutes.

To provide for obstructions in the conduit he proposes to establish reservoirs connected with the main tubes, capable of resisting a pressure of 15 kilogrammes (213 1/10 pounds per square inch), a special compressor could then exercise a total power of $706 \times 15 = 10{,}590$ kilogrammes (23,298 pounds) in overcoming the resistance of any obstruction introduced into the conduit. The escape of air from the conduit is remedied by the establishment of six or seven intermediate compressor plants on the line, which would furnish air at the same pressure as the initial establishment. These stations would be united by telegraph to secure a uniformity of pressure. Intermediate stations could also be established for the transmission of supplementary trains without interference with the main service.

M. Berlier estimates the total cost of the construction of the line as follows:

540,000m³ of Trench, at 1 franc	540,000 francs
90,000 *Tonnes* of Cast-iron, at 160 frs.	14,400,000 "
Laying, at 15 francs per joint	3,375,000 "
10,000 *Tonnes* of Cast-iron, at 160 frs.	1,600,000 "
Laying, at 200 francs per metre (marine portion)	8,000,000 "
Total	27,915,000 francs
or	$5,583,000

The power necessary for the compression of the air is: $T = V P = 9.810\text{m}^3 \times 0.0458\ K \times 10{,}000$ square centimetres = 4,492 kilogrammetres (32,377 foot pounds), or say 60 horse power, in round numbers, per train hour. If the maximum number of transmissions is 20 per hour, a total of 1200 horse-power will be required, M. Berlier then estimates the cost of the two main stations at 3,600,000 francs ($720.000) and the seven intermediate stations, at 1,000,000 francs ($200,000). Adding about $300,000 for contingencies, he thus estimates the total cost of line and plant at 34,000,000 francs, or say $7,000.000.

He estimates the expense of operating the system, including interest and repairs, at 5,500.000 francs ($1,100,000) per annum; and the expense of sending one train, with an annual traffic of 86,400 trains, at 63 francs 65 centimes, or about $12.28. In this estimate he figures upon 12 train departures per hour and 300 days to the working year.

Le Genie Civil, of March 7.

PERSONAL.

RAYMOND DUPUY was appointed, on March 15, General Superintendent of the Minnesota & Northwestern R. R., by President Stickney.

COL. JOHN G. PARKE will act as Chief of Enneers during the absence of Brig. Gen. John Newton.

HERMAN J. LOMBAERT, one time Second Vice-President of the Penna. R. R. and lately deceased, left a will of but forty words, bequeathing an estate of $90,000 to his wife.

L. B. SPEECE, 60 years old, a prominent contrac builder, of Wilkesbarre, Penn., dropped dead at his residence on March 23 from heart disease. He was a Major in the Seventh Pennsylvania Reserves during the late rebellion and fought with distinguished bravery. He was a member of Ely Post, No. 97, G. A. R.

COL. E. L. BOSTWICK died on March 6, at his residence near Tomah, Wis. He was born in Woodstock, N. Y., and had devoted his life to rail-roading. He was Roadmaster of the C. C. D. & M. R. R., and at different periods connected with the N. Y. Central, Michigan & Nebraska Railroads. In 1877 he was appointed superintendent of construction and Roadmaster of the Wisconsin Valley R. R. Col. Bostwick was also superintendent of construction of the Kansas City Bridge.

MR. A. L. ROTHAM, a civil engineer, died recently at Joliet, Ill. He was connected with the late Alex. L. Holley in constructing and building the Troy Steel Works in 1865-66, and in reconstructing those works after they were burnt in 1869. In 1870 Mr. Holley sent Mr. Rotham to Joliet, to construct the steel works there, and in 1873 he went to Scranton, Pa., where he took full charge of the building of the present Lackawanna steel plant, introducing many leading features of his own. For a time he was employed at the Government office of the Mississippi Survey at St. Louis, returning to Joliet in 1881, where, after reconstructing the works in 1883-84, he became superintendent of the Bessemer department. He leaves a widow and four children. He was born in Sweden in 1838.

American Society of Civil Engineers.

The next meeting of the Society will be held on Wednesday Evening, April 1st, 1885.

The Paper by E. L. Corthell, M. Am. Soc. C. E., on The South Pass Jetties.—Ten Years Practical Teachings in River and Harbor Hydraulics, published in the Transactions for October, 1884 (Vol. XIII, page 313 will be discussed.

Discussions have already been received from a number of members.

Discussion is invited on the subjects presented by that paper. Written discussions should be sent to the Secretary so as to arrive, if possible, at the Society House, 127 East 23rd St., New York, not later than March 31st.

JOHN BOGART.
Secretary.

Proceedings of the Engineer's Club of St. Louis.

MEETING OF MARCH 18.

President Moore, twenty-five members and three visitors being present.

On motion of Mr. J. B. Johnson, the Club unanimously adopted the following:

Resolved, That a committee be appointed to consider and report upon the best means of improving the status of civil engineers in the service of the general government.

Mr. McMath proposed an amendment to Sec. 7 of the By-Laws relating to election of members.

Mr. J. B. Johnson read a paper on "The Theory of Car Starters," which was discussed by the Club.

The President read a paper by Mr. Howard Constable on "The Proposed Water-Pipe Line in the Soudan."

Col. S. H. Lockett, who was one of the American officers in the service of the Khedive in 1875-6-7 as Chief Topographical Engineer, being present spoke at some length as to the proposed pipe line and railroad. He was familiar with the country through which the pipe line is projected and did not doubt its successful construction was assured. He thought the railroad projected would be built. The pipe line would aid such construction and be absolutely necessary to its maintenance. The climate was no bar to its settlement, for not considering the lack of water, there were no features of the climate against which objection could be brought. To obviate the lack of water the expedition with which he was connected made drive wells from which constant supplies of good water were obtained,

Prof. Johnson exhibited a French calculating machine, which excited considerable discussion.

THOS. D. MILLER, *Secretary.*

Notes on Topographical Surveys Philadelphia Water Department.*

BY KENNETH ALLEN, C. E.

The City of Philadelphia has suffered for some years from a water supply whose pollution increases yearly, from the sewage and other detrimental matter discharged into the Schuylkill and Delaware Rivers, from which it draws its supply.[1] Experts and Committees have advocated this scheme and that, but no decided steps were taken by the city until the spring of 1883, when the present Chief Engineer appointed Rudolph Hering, C. E., Assistant in Charge of Surveys for a Future Supply.

Of the available sources, the two most favorable appear to be, 1st the Upper Delaware; 2d, the Perkiomen, (a tributary of the Schuylkill), with a possible extension by tunnel and conduit to the Lehigh.

Both of these are ultimately gravity schemes, though in the former case pumping a portion of the supply some forty or fifty miles above the city might prove more economical for the present than the increased length of conduit.

Accordingly, in the summer of 1883, two parties were put in the field to make topographical surveys of portions of the available water-sheds, and to run conduit lines from the proposed sources of supply to the city, and the object of this paper is merely to give a few notes in connection with these surveys that may be of interest.

Each party consisted of 2 transitmen, 1 leveler, 4 rodmen, and 1 axeman. At the end of the season, which consisted of about 170 working days, the work done amounted to—

408 miles steel tape line, (of which 167 miles where conduit lines).
642 miles gradienter and stadia lines.
384 miles levels.
34½ sq. miles topography on conduit lines.
117½ sq. miles topography on water-sheds.

The system pursued consisted, first, in running a series of accurate lines with vernier, tape and stakes 100 feet, or in a flat country 200 feet apart. After this work in a particular locality was done and the levels run, the whole party turned in and sloped as far as convenient on both sides of stations with Abney levels or Linton's clinometers. With these lines to work from, stadia or gradienter lines were extended in general up the valleys, locating spires and other prominent points by triangulation. Meanwhile the level party ran along the ridge roads, locating themselves by triangulating with an azimuth compass, sketching, finding the tops of wooded hills with a barometer, and sloping.

The present season a different course was pursued. It was found desirable, if possible, to complete the field work before January. This included portions of the Perkiomen, Neshaminy, and Tohickon[2] basin—in all some 375 sq. miles.

A series of triangulation stations was first established on the tops of prominent hills and ridges. Five of these were towers from 50 feet to 70 feet high, built each as a well braced scaffold about some tall, firm tree previously shorn of its branches. Three sticks of timber forming a tripod, gave rigidity to the tree, the top of which being sawed off, served as a support for the transit. At a suitable distance from the top a platform was built, and a ladder led to an opening in this from the ground.

The remaining 34 points were simply red and white flags on poles, prominent spires, etc. This system of triangulation was carefully connected with the Coast Survey Stations at Goat Hill, N. J., and Hilltown and Haycock Mt., Pa. Two level parties established benches a mile or so apart over the district, and four transit parties, consisting of but two men each, began topographical work, The last of September the leveling was completed, and four additional transit parties were sent out, The general method pursued was essentially the same as that of the previous year, except that no tape lines were run, and all work was connected with the triangulation station.

The territory allotted to the writer was surveyed in circuits of a couple miles or so in length, roads often being convenient boundaries. Slopes were taken at all points, and the rodman sent out to take further slopes where necessary. Where the ground was moderately open, very little time was lost in good weather by plotting and sketching *in the field*. For this purpose tables 15″×15″ of well seasoned wood were made, and mounted on hollow brass rods shod with steel points. The latter could be hammered into the ground with a stone. These weighed but three pounds each when completed. A light tripod of wood was found firmer than the brass rod, which would sway in the wind.

The final plans are to be 400 feet to the inch, so that a plate was engraved for a sheet 17″×14,″ with a margin, divided into quarter inches. This was held securely on the table by plane-table clips. The engraved lines merely served as meridians, as at T square could not easily be carried. The completed sheets showed the roads, houses, woodland, water and contours. The latter were generally interpolated by eye between points whose elevations were known. Elevations of points for slopes were easily found by the aid of a scale 10″×2,″ made of card-board.

It was found to bring out the pencil lines much more clearly to use colored pencils, viz: blue for water, green for timber, yellow for roads, red for number of the sheet, the needle, etc. In this way it was evident at a glance where one could set up to the best advantage to finish a sheet, how much and what work was done, etc., and the transferring to permanent plans in the office will be comparatively quick work.

In cold or very windy weather the work was done without the use of table, by simply sketching the lines and keeping the notes in a cross-section book, as shown. One party covers from 2 to 3 square miles per week, which amount is increased by the omission of plotting by from 30 to 60 per cent.

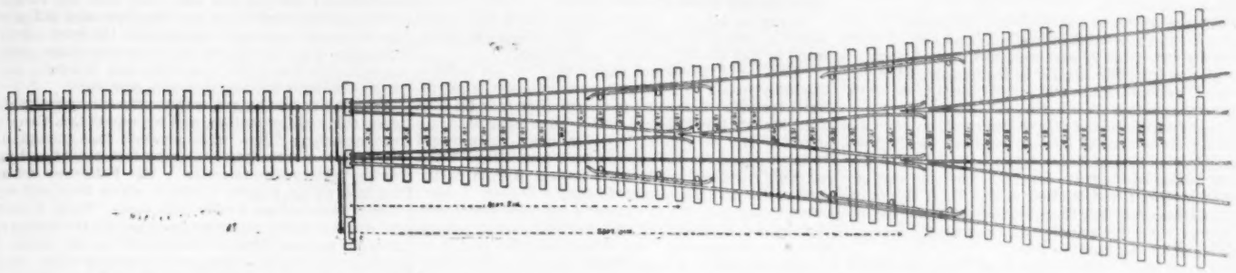
During the past season, besides the recon-

*From Selected Papers of the Rens. Society of Engineers, Vol. 1, No. 2.

[1] The supply from the Kensington Station on the Delaware was discontinbed last summer as being too foul for use.

[2] The Neshaminy and Tohickon are tributaries emptying into the Delaware 13 and 53 miles, respectively, above Philadelphia.

FIG. 73 DOUBLE TURNOUT. No. 8 FROG.



noisance of a route up the Lehigh, the triangulation, and other miscellaneous work, about 345 square miles of topography was taken, and 310 linear miles were leveled with Y level, in about 140 actual working days. The rate of progress depends so largely on the character of the ground, that the above figures are simply a fair general average. The survey covered areas of hilly, rocky, and densely wooded country, while other portions were quite level and open. The greater part is well populated, and villages are found from two to three miles apart.

The outfit for a party consists of 1 transit with bubble, vertical arcs and stadia or gradienter;* 1 level or telemeter rod;† 1 slope instrument;‡ 1 sketch table; 1 azimuth compass; 1 5″ protractor; 1 topographical scale; 1 needle point; sheets to plot on; a cross-section or "sketch" book for bad weather; transit and table books, pencils, etc. A barometer and Pratt range-finder ‖ are at times of great convenience.

The features to be noticed in plotting are inserted approximately to scale in the sketch, with notes of all slopes and bearings to houses, etc. For instance, at sta. 131 + 36, the bearing to the nearest gable of house is S 4½° W; while on the bearing S 31° W the ground slopes downwards at the rate of 0°23′ for about 800 feet. The notes taken at each point between that point and the next are placed on the opposite page. Thus: from 131 + 36 to 138 + 03 (near the bridge), is 667 feet S 44° 27′ E. The rate of descent being 2° 37′, gives a difference in elevation of 30.42 feet. This deducted from 291.42 gives 261.00 feet as the elevation at 138 + 03.

The survey when completed will cover about 500 square miles, exclusive of conduit lines and reconnoisance in the Lehigh basin, and is believed to be the most extensive one of the kind yet made in this country.

ADDENDA

The following is a sample of notes from Sketch Book:

Sta.	Dis.	Bearing.	Vert Ang.	Differ.	Eleva.
155+93	465	S 44°30′ E		+4.10	277.05
147+04	889	S 1°00′ E	−1°02½′	−16.18	292.23
138+03	901	S 34°10′ E	+2°03′	+32.23	261.00
131+36	667	S 44°27′ E	−2°37′	−30.42	293.42
126+61	475	S 44°15′ E	−5°05′	−42.09	333.51

The column headed "Distance," is the distance *on the slope*. In plotting, this is reduced to its horizontal component where the angle is greater than 4° or 5°. A smaller angle for ordinary sights gives a difference inappreciable on a scale of 400 feet to the inch.

Where fence panels are 10 feet long, the distance to one perpendicular to the line of sight is easily found by multiplying the number of panels intercepted in 2° 52′ by 20. Another way is to hold a pencil at arm's length from the eye. Notice by alternately closing the eyes, the number of panels passed over by the pencil. Then.—

Dist. between eyes: Dist. eye to pencil:: number of panels.

× 10: Dist. to fence.

The latter method is very simple and expeditious.

*The former is preferred.
†Two targets may be found advantageous.
‡Linton's Clinometer is the best in design, but the Abney level is better finished, and is more portable.
‖See "Haupt's Topographer."

TRACK.*

BY W. B. PARSONS, JR., C. E.
ROADMASTER SUSQUEHANNA DIVISION ERIE R. R.

(*Continued from page 187.*)

Fig. 73 gives a plan of a double turnout or a "three throw" switch with No. 8 frogs. In order to find the lengths of the switch ties for such a case, the rule is to double the length of each tie in a "single turnout" set and subtract the length of the standard cross-tie. Where the lead rails cross, another frog is required which is called the "crotch frog." The proper angle for the crotch frog and distance from the head block is given in table No. 1.[1] Sometimes the principal frogs are of different instead of the same angle. In this event to obtain the set of switch ties, the lengths of the respective ties in the two sets corresponding to the two frogs are to be added together and from their sum the length of the standard cross tie is to be substracted. Three throw switches are used in yards or places where space is limited; otherwise they are not desirable as they are difficult to maintain.

A crossover is simply a combination of a turnout in each of two parallel tracks with a connecting piece between them. Each turnout is to be laid out according to Table 1. The frogs must be of the same angle. Table No. 6[2] gives the distances between the frog points, which distances are to be reassured on the parallel tracks.

If the parallel tracks are straight the connecting piece between the frogs is also straight, but if the former are curved it is necessary to curve the cross over. But, in all cases whether straight or not the distances given in the table are correct. Opposite each frog as shown in the plans is a guard rail in order to guide the wheel flanges and not allow them to strike or mount the point of the frog.

These guard rails should be about from 11 feet to 15 feet long according as rail is convenient. The flange on one side should be trimmed off so that it can be set up against the spikes and give 2 inches clearance between the head and the gauge side of the track rail. If it is over 2 inch, wheels are liable to hit the frog point. The ends of the guard rail for a distance of 1 foot should be turned up in the blacksmith's shop so that they will be four inches out of line. The rail should be thoroughly well secured by spikes and three knee braces (previously illustrated) placed one at each end just behind the turn and one in the middle. Avoid using clamps or bolts for this purpose and above all the very bad practice of bracing the guard rail by a plank between it and the frog. It throws a side sprain where none should be thrown, that is on the frog; it also forms a fulcrum for the guard rail to rock on and is moreover a make-shift. Sufficient care is seldom given to guard rails, they are either loose or too wide, the latter is an especially common fault as trackmen usually put them in by so many finger's width of clearance—a most variable gauge.

When the side of a frog point shows signs of wear it is due nine times out of ten to a too great space between the guard rail and track rail. Some day a sharp flanged wheel comes along, mounts the frog point and in the wreck which ensues the track is torn up and the cause is assigned as "wide gauge truck," "broken frog," or most probably "unknown," while a few minutes of a track gang on the guard rail would have prevented the occurrence.

Refering to Fig. 70, we will take up in detail the important subject of frogs. As previously stated this figure is but an outline diagram with the names of the several parts, and shows how the two flange ways cross. The determining factor is the angle and dependent on it the frog number as explained above.

A is the "true point" where the sides *A C* and *A B* (prolonged from *D*) meet; but, on account of the impossibility of maintaining such a weak fine drawn edge, the end is cut off so as to give a width in general custom of ½ inch. This is the "actual point" of practice.

The part *C D B* is properly known as the tongue, although the name "point" is frequently extended so as to include the whole of the tongue, but the two names will be always kept separate in what follows.

The base *B C* of the tongue is called the "heel." The side pieces on which the wheel treads rest till they get so far past the point as to be carried by the tongue, are called "wings." The passage between the wings and the point is called the "flange space," and that part where the wings approach closest together and become tangent to the line of the sides of the tongue prolonged, is called the "throat." The width of the throat should be the same as the flange space.

(TO BE CONTINUED.)

CORRESPONDENCE.

Egyptian Water Supply.

BELLEVILLE, ILLS., March 20th, 1885.

EDITOR ENGINEERING NEWS.—In Col. Prout's very interesting article entitled from "Suakim to Berber," he indicates in his conclusion that he doubts the feasibility of the water supply scheme proposed by the Worthingtons. He seems to base his opinion of its infeasibility upon the assumption that no sufficient supply of water can be had at Suakim; saying "As the line advances the pipes must stand practically empty until the Nile is reached and water pumped back."

In this connection allow me to say, I was not at Suakim during my Egyptian experiences, but was for nine months at Massawah and in its vicinity. This is a region very similar to that around Suakim. I fortified Massawah, and tried to put it in condition to stand a seige. Of course one of the important questions was the water supply.

The solution of that question had already been partly effected by Munzinger Pacha, former governor of Massawah. He had dug several large wells on the sand plain of the main land, at distances varying between ¼ of a mile and 2 miles from the shore line of the Red Sea. From these wells water was raised into tanks,

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[1] See "Turnouts."
NOTE. [2]Table No. 6, is Table No. 3. in "Turnouts.")

whence it ran by gravity through iron pipes, to a large cistern in Massawah.

With the object of determining the source of the water which supplied these wells, I ran a line of levels from the shore line to each well, and upon dropping a plumb-line from the surface to the bottom of the well I found the depth of the well exactly equal to the elevation of the surface above sea level.

From this I concluded that the water of the wells was nothing more than the filtered waters of the Red Sea, and therefore inexhaustible, in quantity. It was perfectly wholesome; a little brackish, but one soon got accustomed to it, and learned to like it. If this is the case at Massawah, why should it not be so at Suakim? And if so, then the question of water supply does not depend upon reaching the Nile.

One more word on this subject and I will no further trespass upon your valuable space. Do not all the sand islands of the Gulf Coast give good water by digging wells within even a few hundred yards of the sea line? Such was the case on Amelia Island, Fla, where I once built a fort; also on Dauphin Island, Mobile Bay, and on the narrow point of land upon which Fort Morgan stands; and I think the same holds true for all the sand islands of the southern coast Respectfully

S. H. LOCKETT.
Late Col. of Engineers,
Egyptian Army.

Index to Periodical Literature.

SOMERSET, KY. March 18, 1885.

EDITOR ENGINEERING NEWS:—I think your "Index and Periodical Literature" a very valuable feature of your paper, and I hope you will continue it and make it as complete as practicable.

I write to suggest the use of certain conventional signs in connection with the index, which I think would add very greatly to its value. I use them in my "Library Index," (Burr's) from the fly leaf of which I copy as follows:

"*. Very fully illustrated.
x. Illustrated but not fully.
v. A very full and valuable article on subject.
v^1. An article of much value but not very full.
v^2. Contains information worth indexing, but not very valuable.

If the *v* is overscored thus, $\overline{v}$, the article is of a *practical* character; if underscored thus $\underline{v}$, the article is mostly theoretical; both marks may be used thus $\underline{\overline{v}}$. *, indicates a very full and complete article, fully illustrated, giving both the theory and practice of the subject treated of."

It is probable that a better system of symbols might be devised, especially from the printer's standpoint, but these may suggest to you what is needed.

S. W.

While we may later adopt a method similar to that outlined by "S. W.," as this index developes, we publish the suggestions for general use or criticism.

ED. ENG. NEWS.

The Stability of the Washington Monument.

NEW YORK, March 20, 1885.

EDITORS ENGINEERING NEWS.—Having already referred to the foundations of the Washington Monument in the pamphlet from which you have given copious extracts, I would next refer to the material on which this foundation rests. This material is referred to as follows by Col. Casey in his address of presentation:

"Indeed the bottom of the new work is only two feet above the level of high tides in the Potomac, while the water which permeates the earth of the Monument lot stands six inches above this bottom. The foundation now rests upon a bed of fine sand some two feet in thickness, and this sand stratum rests upon a bed of boulders and gravel. Borings have been made in this gravel deposit for a depth of over eighteen feet without passing through it, and so uniform is the character of the material upon which the foundation rests that the settlements of the several corners of the shaft have differed from each other by only the smallest subdivisions of the inch. The pressures on the earth beneath the foundation are nowhere greater than the experiences of years have shown this earth to be able to sustain, while the strength of the masonry in the foundation itself is largely in excess of the strains brought upon it.

The stability of this base is assured against all natural causes except earthquakes *or the washing out of the sand bed beneath the foundation.*

* * * * * It is sufficient to say, that although the dimensions of the foundation base were originally planned without due regard to the tremendous forces to be brought into play in building so large an obelisk, the resources of modern engineering science have supplied means for the completion of the grandest monumental column ever erected in any age of the world."

We also see in the Washington *Evening Star*, of Feb. 21st, 1885, the following:

"Is it necessary to fill up Babcock lake immediately to insure the stability of the Washington monument?" asked a *Star* reporter of Col. Casey the other day.

"I disposed of that subject in my last report," said the colonel, with a weary air, as if he had said and heard enough about the monument.

"I want to tell the readers of the *Star* a little more about it," urged the reporter. "All of them are interested in both the lake and the monument."

"Well," said the colonel, resignedly, "in my opinion the lake should be filled as a precautionary measure, but it makes no difference to me whether it is filled or not. My work is finished, and I have expressed my opinion. If it were filled, however, not a thing would be left undone for the monument's protection. Then we could trust in Providence to protect it from earthquakes, for nothing else could topple it over. I don't mean to say that the existence of the lake endangers the stability of the monument, for both might remain for ages; at the same time it undoubtedly should be done away with for precautionary reasons. The monument belongs to the government, and it can do as it pleases, of course. The pond is valuable for carp breeding and for a skating ground, and if these reasons outweigh the others, well and good."

"Now, I'll tell you," continued the colonel, "why I think the existence of the lake may endanger the stability of the monument. All along during the construction of the latter it was observed that when any motion in the structure took place, due to the addition of weight, the two north corners were the first to settle. Why should they settle first invariably and then the others follow? Simply because the congugate pressures on that side were reduced by the falling away of the earth. The foundation of the monument has been strengthened and well strengthened, and is now able to support the weight of the monument, and that is all. *The foundation is built right in a marsh. The water stands several inches above the bottom of that foundation, and the earth upon which it stands is the finest sand imaginable—as fine as any ever used on writing paper. Imagine the pressure upon the stratum of earth on which the foundation rests with the same dimensions as that foundation. It is something enormous. Now, what prevents that section or stratum from spreading out under this weight and allowing the structure to settle?* Simply the weight of the earth which is contained above a line drawn from that stratum to the surface at the angle at which the earth naturally falls, the angle depending upon the character of the earth. If it were rock it would stand perpendicular. You can catch the idea by recalling the formation of a railroad cut. The earth on the sides of the cut will roll down until it reaches the natural angle. Very well, then. If the weight of this earth is unequal the stratum is liable to be squashed out, as it were, in the direction of the least weight. That is, exactly the case if the lake is allowed to remain. It has the effect of lessening the pressure on that side. The angle which I referred to would bring the line, if drawn to the surface, through part of the lake, showing an unequality of pressure, because the earth would be removed to form that part of the lake. Besides, I have always noticed when the water is drawn off that there are a number of springs bubbling forth from the monument side. What is to prevent these springs, which have their origin in the vicinity of the monument, from gradually drawing away, as they find an outlet in the lake, the fine sand from beneath the monument and allowing the structure to settle. These two closely allied reasons led me to recommend that the lake be filled. I haven't an idea that the monument will fall. If it does fall, and from natural causes, it will not take a sudden tumble, but will be years in toppling over.

There will have to be some gradual undermining, similar to the possibilities I suggested. If these possibilities are done away with there is no reason for alarm."

"How much has the monument settled?" asked the reporter.

"Only about four inches," was the reply, "and the settlement has been equal all round. We have kept a record of the daily movement or settlement of each corner since the foundation was strengthened. As I said, the north corners have always started first, and the others followed."

Now here is the tallest structure in the world, having the greatest base pressure of any structure now standing, resting on a two-feet layer of the finest sand "imaginable;" and this sand under water, with trickling springs that are liable to draw away the sand. From the description given and the accounts of surrounding clay, this sand is not so far removed from a quicksand as to be above suspicion.

Now that class of foundation is uncertain and just as uncertain after it has stood twenty years as the day after the structure was completed. Two years ago I had occasion to straighten up and strengthen a pier that had carried its load perfectly for 23 years. Suddenly and with no new load or strain upon it, and in the middle of summer, this pier acted as if it was tired, had carried its load long enough and laid down. We found under this pier just the same material that Col. Casey describes as being under his monument. When Col. Casey got to this fine sand we can easily imagine that it was easier to cover it up than to take it out. But, if he had used "the resources of modern engineering science" to which he has so eloquently referred, he need not have left that sand in place, and then gone to the expense of filling up Babcock Lake.

With the lake filled up, what will he do with the Potomac River? Filling the lake may turn the subterranean water courses in a new direction; and filling up the lake won't remove the water from the sand. Boatmen know that if their craft get on a shoal of fine sand, a rocking motion of the boat will move the sand, and they sometimes free themselves in that way.

Now, in this monument, we have the wind pressure to cause this rocking motion, and we repeat Col. Casey's own question: "Now what prevents that section or stratum from spreading out under this weight and allowing the structure to settle?" The buttresses act as braces or struts, and the blocks on which they rest are simply foundations for the buttresses. They extend but five feet under the monument, and all the pressure from the monument and the material directly under it tends to force these footings and buttresses apart. And then they rest on a loose, saturated sand.

In strengthening this foundation, "to tunnel under the shaft and go down to a good foundation, and fill the excavated portions with a good beton," meet the requirements of the case. But none of this has been done even for a diameter of 55 feet under the shaft. Forty-five feet square under the shaft is still unfilled, and under this is two feet "of the finest sand imaginable," permeated by springs which are liable to waste this sand away. And this is the material which is supposed to carry, for all time, the great weight of what Col. Casey calls, "the grandest monumental column ever erected in any age of the world."

JOHN C. GOODRIDGE, JR.

Freezing of Water Mains.

PAWTUCKET WATER-WORKS, PAWTUCKET, R. I.
March 23d, 1885.

EDITOR ENGINEERING NEWS.—In reply to the communication of Fayette Marsh, (issue of March 21,) in regard to freezing of pipes, I give the practical working of the services on our works.

Our pipes are laid 5 feet deep and I find the frost is 4½ feet, the *mains* have not frozen but the *services have* to some extent. After careful examination without going into any scientific experiment I attribute the "Cause and Effect" to the same result that is produced in freezing Ice Cream, i.e., by the rapid melting of the ice (with salt, etc.) we drive the cold into the cream, on the same principle when the frost is deep in the earth the warm days drive the cold down and while it may not freeze the earth solid it creates a temperature that will freeze the water in the pipes. We have had occasion to dig to the pipes and while we found the earth frozen to within 6 or 8 inches of the pipes the water in the pipe was solid and the earth around it was not.

Hoping that my experience may throw a ray of light on the subject, I remain yours with respect,

EDWIN DARLING, Supt.

W. H. Richards, C. E., of New London, Conn., sends us a communication explaining the above phenomenon in a similar manner. ED. ENG. NEWS.

Freezing in Water Mains.

WILLIAMSPORT, IOWA, MARCH 23, 1885.

EDITOR ENGINEERING NEWS:—In your last issue appeared an article from Fayette Marsh of Stillwater Minn., relating to the fact that water pipes are closed by frost more frequently in mild weather of spring than during the intense cold of winter.

I am familiar with this occurrence especially in the case of service pipes, and have explained it on the following principle. Solid substance, upon becoming liquefied, absorbs heat and intense cold results; the warm sun melts the snow or surface frost, and its frozen bed conveys the resulting cold to the susceptible material beneath it, frequently penetrating to a depth of several inches, entirely free from frost before this sudden change of temperature in the atmosphere.

In confirmation of this theory, I would cite my experience with frozen street mains, of which I have had about a thousand feet this month, and which I have succeeded in getting open without the loss of but a single length. We have many street mains imbedded within the frozen earth, on account of shallow covering from 3 to 5 feet), and the unprecedented depth of the frost, in some streets 5½ feet. Most of these mains are kept open by the velocity of the water, while service pipes are closed along both sides, unless constantly open, but the slush that forms within them is carried along and accumulates in lines having very little circulation, where it lodges at intervals and soon stops the supply, and so remains until a "mild spell," when thorough congelation takes place and the pipes are river from end to end.

What becomes my custom, as soon as such a condition is discovered, is to endeavor to get it restored to use as soon as possible. This is accomplished by burning test holes down to the main, with wood tapping a ¾ hole and, by means of a stiff wire locating the obstruction, burning that out and thus proceed until the completion of the work.

I would like to hear from the brethren in regard to the most efficient method for thawing frozen mains and services pipes.

J. H. McMINN,
Supt. Water Works.

Grade on Side Tracks.

ATLANTA, GA., March 23, 1885.

EDITOR ENGINEERING NEWS:—I see Mr. Frank P. Davis's formula and experiments give 11.88 feet per mile as the angle of repose of cars on track, but concludes that 15 feet per mile would give little or no trouble. Trantwine puts it from 16 to 24 feet per mile, and Mahan says 21.12 feet per mile. We have sidetracks here on a grade of 31.7 feet per mile. Has any other road got that much? No trouble has been caused here. This is on tangent. Respectfully.

A. T. MCDANIEL,
City Asst. Engineer.

Creeping of Rails.

S. F. AND W. R. R.,
WAY CROSS, GA., March 18th, 1885.

EDITOR ENGINEERING NEWS.—In reply to the communication of Mr. C. R. Wise, of the Brunswick & Western Railway, in your issue of the 14th, I will say that where iron rails are used either method he suggests (preferably slotting at center) would prove satisfactory but with steel rail the case is different. It is quite rare for a steel rail to break from a hole drilled in its neutral axis, but breaks occur frequently from flaws in the base of rails, or from contraction of cross-section or from blows from spike mauls at that particular part, and my experience has shown that slotting the base of a steel rail, however carefully it may be done, has a greater tendency to weaken the rail than drilling bolt holes for angle plates. I agree with Mr. Wise that the case of the St. Louis Bridge has a different bearing from that of ordinary track, but I think, with an additional provision at the end of each span for the expansion and contraction of the span itself, that the plan we are using will work satisfactorily.

I would be glad to learn through your columns what expedient has been successfully adopted on the St. Louis bridge. Respectfully,

H. W. REED.

To Whom it May Concern.

MEKE IMPERIAL COAL MINE, CHIKUGO, JAPAN.
January 27, 1885.

EDITOR ENGINEERING NEWS.—If not too much trouble, will you kindly furnish us with answers to the following questions:—

1. What firms make creosoted timber?
2. What firms make boring apparatus, used in the Penn., & N. Y. oil regions?
3. What books or pamphlets in which the boring method and apparatus are accurately described in detail?
4. What firm make screw piles?
5. Where is the locality of Lake Ponchartrain across which many miles of wooden pier have been built for the purpose of transporting rails? (I saw a notice of it in a column of your Journal some time ago.)

Answers to the above will be gratefully received by

Yours respectfully,
T. DUN. M. E. S. B. Engineer.

[1. The Eppinger and Russell Creosoting Works, Brooklyn, N. Y., and Vanderbilt and Hopkins 120 Liberty St. New York City, will supply the world with creosoted timber if necessary.

(2.) W. S. Watson, Bradford, Pa., and the Oil Well Supply Co., Bradford, Pa.

(3.) See elaborately illustrated catalogue of last named firm.

(4.) The Driven Screw Post and Pile Co., 171 Broadway, New York City.

(5.) Due north of, and about 5 miles distant from, the City of New Orleans, La.

More complete answers to the above queries will be published if furnished. ED. ENG. NEWS.]

PENNSYLVANIA R. R. COMPANY, ALTOONA, PA.
MARCH 24, 1885.

EDITOR ENGINEERING NEWS: In your edition of March 14th, 1885, Mr. F. P. Davis gives a solution of problem on "Grade for Side Tracks," in which he assumes "the accelerating force of gravity equal to $\frac{V}{5280} \times W$", or $W \times$ tan. of angle of grade inclination.

By the accelerating force of gravity, we take Mr. Davis to mean the force necessary to move the body down the plane, or what is the same thing in this case, the force that prevents the body from moving.

From the diagram usually used to explain the effec of a body sliding down an inclined plane, it is evident that this force, represented by P, is equal to the weight × sin. *a* (the angle made by the vertical W and the component normal to the plane), and not W tan. *a*, as Mr Davis has put it.

a being a very small angle, the tangent does not differ materially from the sine, and both formulæ will give practically the same result.

The equating of this formula with a resistance of 4½ lbs. per ton, is however in error for a grade at which trains will move without the application of power.

The resistance at a speed of 15 miles per hour, is for loaded cars, about 4 lbs., and for empty cars 5¼ lbs. per ton.

The starting resistance is of course very much in excess of this amount, and equating with its proper value, we would have a greater value of V as a starting gradient.

The scale tracks of the P. R. R, have usually grades from .6 to .7 per 100. On these tracks cars will start under ordinary circumstances without the use of an engine. Very respectfully,

E. T. FISHER.
T. J. BRERETON.

Creeping of Rails.

SOMERSET, PA., March 15, 1885.

EDITOR ENGINEERING NEWS.—In your March 14th edition of ENGINEERING NEWS I see a communication from Colin R. Wise, in which he suggests the spiking of one end of the rail only, leaving the other end loose, to remedy the evil of creeping rails. The query to me is why one end only? The practice I have seen usually employed and which I have used while connected with the P. R. R. & S. V. R. R., was to spike both ends of the rail allowing for expansion in placing the spike. If a proper allowance is made in originally laying the track, making due allowance for the extremes of temperature, and the rails are spiked in the manner to which I refer, making each rail act the part of an independent item, with the additional safeguard of adding guard-rails chairs to the outside and inside of rails on heavy curves, I found that if the ties were solidly imbedded in the ballast it was impossible for the rails to slip or throw the track out of line. On the bridge and trestle crossing the of Shenandoah River at the Va. Midland R. R. crossing, and on some of our long trestles on down grade where it was necessary to slacken the speed of trains, the slipping of the train tended to push the rails in the direction of down grade more than the same effect produced on the up grade, this tendency was overcome by the addition to the above expedient of planting ties five feet deep, at each end of a joint tie just outside the rails with the top of the planted tie level with the surface of the track tie, for five or ten rail lengths back of the crossing and trestle, with good results, Yours truly,

U. S. LUTZ,
Resident Engineer, S. P. R. R.

LITERATURE.

Journal of the Association of Engineering Societies, March, 1885. Contents: "The Separate Versus the Combined System of Sewerage, as Exemplified in the Drainage of Hyde Park," by Benezette Williams. "Ventilation of Stables," by Augustine W. Wright. "The Eccentricities of the Transit or Theodolite, and their Influences on Horizontal Angles," by John Eisenmann.

Journal of the Association of Engineering Societies, February, 1885. Contents: "Brief Sanitary Matters in Connection with Isolated Houses," by E. W. Bowditch. "Sewerage and House Drainage in St. Louis, by Rob't Moore. "Rapid Construction of the Canadian Pacific Railway," by E. T. Abbott. "Progress in Astronomical Telescopes," by W. R. Warner. "Protection Against Fire," by C. T. Aubin. "Tunnels and Intercepting Sewers for the Sewerage of Cleveland," by J. H. Sargent.

Transactions and Proceedings, American Society of Civil Engineers, Dec. 1884. Contents: "Experiments with New Apparatus on Journal Frictions at Low Velocities.' By A. M. Wellington, and discussion on same by R. H. Thurston, W. S. Auchincloss, D. J. Whittemore, Wilson Crosby, Beauchamp Tower, Henry R. Towne, Chas. Paine, F. M. Wilder, John W. Cloud, Theodore Cooper, C. E. Emery, W. H. Paine, F. Collingwood and A. M. Wellington. "On the Real Value of Lubricants, and on the Correct Method of Comparing Prices," by Robert H. Thurston.

Album of Designs, Phœnix Bridge Company, J. B. Lippincott & Co, Phila., 1885.

While this is in purpose a trade catalogue issued by the Phœnixville Bridge Co., it is a bit of enterprise and workmanship in book-making well worth noticing. The illustrations are mainly phototypes, elegantly executed, and showing the works of the company and a number of finished structures built by them, with all their natural surroundings, and with the truthfulness a sun-print alone can give. These views include the Kinzua Viaduct, the Catskill, Harlem River, Chaudiere, Susquehanna (at Sunbury) Girard Avenue, (Phila.) and the Rondout Bridges, and also various views of the Metropolitan Railway in New York, and of the works of the company at Phœnixville, Pa. In connection with these phototypes are a number of designs, showing the usual forms of bridges, etc. constructed by this company. The text, which is in elegance in keeping with the illustrations, describes the various works shown, gives a history of the works, general specifications for railway bridges, a list of completed works, etc.

THE April number of *The Magazine of Art* is teeming with art pictures and art papers. A departure, more nearly in our own line of journalism, is the paper on American Art Industries, showing the decided advance made in the United States in the last ten years in the artistic treatment of household furniture and appliances. This first paper is devoted to "heating apparatus," and the accompanying engravings proves how handsome so common an appliance as a stove can be made when its detail of form and ornamentation is developed by an artist hand. The several papers forming the body of this number, on the Older Churches in London, Fashions in Waists, Some Venetian Knockers, Artist in Corsica, etc., etc., are superbly illustrated, and in matter such as we always expect from this excellently conducted art magazine. Published by Cassell and Co., limited, 739 Broadway, New York.

Tables for Field Engineers, Designed for Use in the Field. Tables Containing all the Functions of a One Degree Curve, from which a corresponding one can be Found for any Required Degree. Also Tables of Natural Sines and Tangents. By AMOS STILES, C. E. Published by the author, Phila., 1885.

This book of tables forms a thin, handy volume bound in leather. It contains three different sets of tables, their explanations and rules for use. Table I gives the radius and its logarithm for every degree of curve, to single minutes, up to 12 degrees; every two minutes up to 22 degrees; every ten minutes up to 41 degrees, and every thirty minutes up to 51 degrees. In addition to the radius and logarithm is given the tangential distance or offset, to a point on the curve at the end of the first 100 feet from the tangent point; also the middle ordinate for a chord of 100 feet. Table II contains the chords, versed sines, external secants, and tangents to a one degree curve, for every minute of central angle, from 0° to 90°. Table III contains natural sines and tangents to every degree and minute of the quadrant, extended to seven places of decimals.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E.: M. INST. C. E.

(CONTINUED FROM PAGE 157).

DCCXXXIII, KNOXVILLE, TENN.

Knoxville, Tennessee, in lat. 35° 50′ N., long. 83° 55′ W; the county seat of Knox Co,, is at the head of navigation on the Tennessee River about 1000 feet above the sea water-works were built in 1883 by a private company, taking the supply from the Tennessee River. The water is pumped by two Davidson compound horizontal plunger pumps, of 20 inch water plungers aud 24 inch stroke, having each a daily capacity of 1,500,000 gallons to a reservoir of 3,000,000 gallons capacity, constructed in earth with a division wal forming two compartments. The inner slopes are 1½ to 1. When first filled, the bottom of the reservoir, being of clay overlying a cavernous limestone formation, broke away into caverns sixty feet below. Five similar breaks subsequently occurred. After the first of these breaks the reservoirs were lined with brick laid in mortar made of partly set cement and river sand, with mud and sticks in it This did not prove effectual, and the work has been reconstructed under charge of A. H. Martine using Portland cement and clean sand.

Distribution is by nine miles of cast-iron pipe with 82 fire-hydrants, 3 meters and 391 taps. Service pipes are of galvanized iron. The daily consumption is 500,000 gallons. The city pays $50 yearly for the use of each hydrant. The cost of the works has been $130,741. The bonded debt is $125,000 at 6 per cent. The yearly expenses of maintenance are not given, the receipts are $10,500. The population in 1880 was 9,693.

Sam. McKinney is President, John M. Brooks, Secretary and A, H. Martine, Superintendent..

DCCXXXIV, STAMFORD, N. Y.

Stamford, Delaware Co, New York, in lat. 42° 15′ N., long. 75° W. is on the Delaware River in a mountainous district 1800 feet above the sea. Settled in 1790, it was incorporated a village in 1870.

Water-works were built in 1883 by a private company after plans of W. B. Rider. The supply is taken from the head water of the Delaware River one mile from its source, the area drained being about three square miles. A dam 12 feet high and 75 feet long of masonry, laid in cement, built across the stream forms an impounding reservoir 150 feet above the village. The water after passing through a wire screen and a filter of sponge and charcoal, is distributed by 3 mile of

cast-iron pipe of 8 to 4 inches diameter, with 13 fire-hydrants and 46 taps. Service pipes are of lead.

The village pays $15 annually for the use of each hydrant. The works have cost $20,000, which is the amount of the capital stock of the company. The bonded debt is $5,000 at 6 per cent. The population in 1880 was 522 and is now given as 700. S. E. Churchill is President of the company, and F. G. Rulifson, Secretary.

WATER.

JEFFERSON, Ill., is urging Councils to adopt the proposition of N. Sheldon to establish water-works in the village.

THE Ohio Legislature, on March 17, passed a bill authorizing Granville, Licking Co., to borrow $15,000 to construct water-works.

CLAREMONT, N. H., has appointed a committee to act with the selectmen in investigating the subject of a water supply.

THE Phillip Water Co., of Franklin Co., Maine, will commence work this spring. The reservoir will be located on a hill about a mile from the village.

THE Nashville, Tenn., Board of Public Works will immediately purchase water-meters, says the *American* of March 16. They are to be located in factories and among large consumers. The rates laid down in the law are, 10,000 gallons and upward, 15 cents per thousand; between 5,000 and 10,000 gallons, 20 cents; between 1,000 and 5,000, 25 cents; fractional part of 1,000 gallons, 30 cents.

PROF. OLIN LANDRETH, City Engineer of Nashville, has located the pumping station of the new water-works system. It is on an island in the Tennessee river, made up of coarse gravel and sand, on which a filtering chamber 130 x 10 x 6 feet was built some eight years ago, but never used. The new Holly-Gaskill pumps are now to be located near this basin. Prof. Landreth recommends that the filter be increased to 1,400 feet in length, and the city has appropriated $65,000 to put this filter in order.

CITY ENGINEER FORCE, of Cleveland, O., in his annual report outlines a plan for improving the sanitary condition of the river by freeing it from sewage pollution. His scheme is to build intercepting sewers and a conduit leading to the lake, and to produce a sufficient current by pumping. He roughly estimates the cost of construction of the main conduit and pumping plant at $400,000, $300,000 being for the conduit and $100,000 for the pumps, boilers and buildings, etc. His scheme can be extended as the city grows. He recommends an expenditure of $1,000 to make the necessary examinations and borings.

NEWS OF THE WEEK.

Miscellaneous.

No Oil in British Burmah.—The Borongo Company, of Burmah recently imported from England valuable machinery for sinking oil wells and for refining the oil product, but, after a year's effort, the Government reports just published contain the statement that "so far attempts to obtain oil in paying quantities in British Burmah have proven a failure."

A New Polar Chart—A chart of the Polar regions, from Baffin's Bay to Lincoln Sea, has been received from Washington. The chart shows the most recent discoveries made by expeditions, including all those from 1871 to that of Lieutenant A. W. Greely. A number of the charts for distribution are in the hands of Lieutenant Wyckoff, Hydrographic Office, Phila.

Tin Mines in West Virginia.—It is not generally known that there are in successful operation in West Virginia two tin mines. One is near the city of Huntington, in Cabell County, and the other about five miles from Grantville, in Calhoun County, on Laurel River. Unfortunately, it is a considerable distance from a railroad, and on very bad ground for hauling. The Calhoun County mine, which is the most extensive, is owned by State Senator T. J. Farsworth, of Buckhannon, Missouri, and B. Ridgeway, of Staunton, Va. The tin is practically inexhaustible. The opening of the mine is directly in the face of a great hill. The rock is extremely hard, and blasting and drilling are constantly necessary. The product is of a bluish-gray color. Primitive machinery for the manipulation of the ore is in operation. P. B. Wilson, of Baltimore, assayed the ore, and found it to contain 42 per cent of tin. As soon as the necessary arrangements can be made smelting-works on an extensive scale will be erected. Eastern capitalists own the mine in Cabell County. It is believed that the Calhoun County vein extends miles across the country to the Great Kanawha River.

The Novelties Exhibition—The Board of Managers of the Franklin Institute have decided that the Novelties Exhibition to be held in their building, at Thirty-first and Lancaster Avenue, Phila., shall open on Tuesday, September 15, and close on Saturday, October 31. Henry R. Heyl will act as chairman and general manager. The Novelties Exhibition is to be devoted to such recent discoveries, inventions and improvements in the sciences, arts and manufactures as may be deemed worthy of a place in the exhibit, and which were not admitted to the Electrical Exhibition last Fall.

A Twenty-four Hour Clock.—A very interesting clock has just been fixed opposite the National Provincial Bank in Bishopsgate Street, London. It is on the twenty-four hours principle, and is remarkable as possessing probably the simplest method which has yet been introduced for indicating time upon the new enumeration. It has only one hand, the long minute hand, and the figures around are placed as heretofore; instead, however, of indicating the hour, they indicate the minute only, which are marked from five to sixty. The hours are shown on a sunk dial revolving under the upper dial, a space being left in the upper dial in which the next hour figure comes forward instantaneously upon the minute hand completing the circuit of sixty minutes. In short the solitary hand marks the minutes and the sunk space show the hour.

The N. Y. State Land Survey.—The work of this survey is very difficult, as it covers the mountainous districts of Northern New York, and the Adirondack wilderness. This region abounds in magnetic iron ores and this effected the needles of the colonial surveyors. So the old lines are more or less crooked. The old line trees are also fast disappearing; those of 1768 and 1772 are nearly all dying or dead. The work of the Adirondack survey is to replace these trees with granite monuments. Of the 750,000 acres of wild State lands, only 175,000 acres are tax lands under the sale of 1881. This leaves 575,500 held by the State under old titles.

Richardson's Carbonized Stone Cement Pipe is made by the following process:—One-fifth part of best English cement is mixed with four-fifths of Rosendale or Louisville cement. This mixture is then mixed with the best sharp sand in the proportion of one part cement to two parts sand. The sand is free from loam. The mixture is moistened and placed in cast-iron moulds and tightly packed.

The pipe when well formed comes beautifully out of the moulds and is placed in air-tight chambers. Here it absorbs carbonic acid gas which comes from a furnace in which charcoal is burned. The gas is cooled by passing through a cooler immersed in cold water. The soft pipe absorbs this gas and becomes very close and hard, after which it is dipped in water or sprinkled. The oxygen from the water hardens the pipe still more, so that it stands at last a perfect stone, hard as the natural rock.

The pipe hardens the longer it is used, and in years becomes as hard as the original cement rock from which the cement was made. Cement is made by burning the cement rock which expels the carbonic acid gas. Mr. Richardson's process restores this gas and thus reconverts the dissolved elements into the original rock.—Lynn, Mass., *Item*.

Contracting.

Steam Rollers.—The County authorities of Chattanooga have concluded to buy a steam roller to use on the country roads.

Santa Fe Capitol Building.—Proposals will be received by W. W. Griffin, Santa Fe, until May 15, for, constructing the east wing of the New Capitol building

Asphalt Pavements.—Chattanooga property owners at a meeting held March 16th, have concluded to adopt a street paving of Trinidad asphalt, and the matter is now being pushed.

Stone Arch.—The committee on roads and bridges of Minneapolis, Minn., have opened the following bids for the construction of a stone arch over Bassett's Creek, on Third avenue north, in that city: Jeremiah Crimmins, $4.49 per cubic yard stone masonry; McDermott & Hickey, $4,700 for the bridge, making a little more than $10 per yard; J. J. Palmer, $6.93 per cubic yard; R. M. Riner, $6.48 per cubic yard; T. F. Hanlan, $5.50 per cubic yard; William Mauer, $7.25 per cubic yard; Thos. Daly, $9.75 per cubic yard; Dennis Thainor, $8.73 per cubic yard; E. E. Munson, $7.75 per cubic yard.

Nashville, Tenn., Boilers. On March 16, the Board of Works opened bids for boilers for the new pumping station. The bidders were:

Stewart Boiler Works, Worcester, Mass., $12,600 and $12,250; Charles Ward, Kanawha, $14,500 and $12,000; Butman Furnace Company, Chicago, $9,188.40 and $9,-268.40; Tanner & Delaney, Richmond, Va., $13,355.10; Edge Moor Iron Company, Wilmington, Del., $16,900; Babcock & Wilcox, New York, $14,341; Safety Steam Generator Company, New York, $11,560; Heine Safety Boiler Company, Chicago, $14,870, $15,375, $15,270; Warden & Mitchell, Philadelphia, $10,000 and $10,050; Erie City Iron Works, Erie, Pa., $6,250, $6,150, $7,600, $7,700, $8,525, $8,625, $9,900 and $10,000.

Ohio Buildings.—The Ohio Legislature, on March 17, passed bills, authorizing Springfield to borrow $150,-000 to erect a market house; Hartwell, Hamilton Co., to build a town-hall; the Hamilton County Commissioners to borrow $175,000 to complete Court-house.

Boston Contracts for Hardware.—Bids were opened on March 19th, by the Boston Water Board, for such iron, brass and composition castings as may be required during the next financial year. The bids were as follows:

Sidewalk service-pipe boxes, per pound: Chelmsford Foundry Company, 2¾ cents; Mechanics' Iron Foundry Company, 2¾ cents; Boston Machine Manufacturing Company, 3 35-100 cents; Osgood & Hart, 2¾ cents; Davis & Farnum Manufacturing Company, 2¾ cents.

Other iron castings, per lb.: Chelmsford Foundry Company, 1¾ cents; Mechanics' Iron Foundry Company, 2¼ cents; Boston Machine Manufacturing Company, 2 37-100 cents; Osgood & Hart, 2 cents; Davis & Farnum Manufacturing Company, 2¼ cents.

For old iron received, the offers range from 55-100 cents to 75-100 cents.

Brass and composition castings, per lb.: Boston Machine Manufacturing Company, brass 15 cents; composition, 17 cents; old iron and composition castings received, 10½ cents, brass and composition turnings received, 9½ cents; Stephen Anderson, brass, 16 cents; composition, 18 cents; old brass and composition castings received, 12 cents; brass and composition turnings, 8 cents.

On a basis of 250,000 pounds of sidewalk service pipe boxes to be supplied, less 50,000 pounds of old iron to be returned, the total bids are: Chelmsford Foundry Company, $6,575; Mechanics' Iron Foundry Company, $5,875; Boston Machine Manufacturing Company, $8,100; Osgood & Hart, $5,250. Davis & Farnum Manufacturing Company, $6,525. The contract was awarded to Osgood & Hart.

On a basis of 400,000 pounds of iron castings to be supplied, less 150,000 pounds of old iron to be returned, the total bids are: Chelmsford Foundry Company, $6,600; Mechanics' Iron Foundry Company, $7,875; Boston Mechanics' Manufacturing Company, $8,655; Osgood & Hart, $6,650; Davis & Farnum Manufacturing Company, $7,950. The contract was awarded to the Chelmsford Foundry Company.

On a basis of 5,000 pounds brass castings and 10,000 lbs. composition castings to be supplied, less 4,700 pounds old brass and 4,400 pounds brass and composition turnings to be returned, and the total bids are: Boston Machine Manufacturing Company, $1,538.50; Stephen Anderson, $1,684. The contract was awarded to the Boston Machine Manufacturing Company.

Boston Sewers.—Boston Councils are debating under whose management the improved system of sewerage should be placed. It is now in the hands of a special committee; some councilmen object to placing it under the Superintendent of Sewers because it would deprive them of a controlling voice. Mayor O'Brien thinks it should properly remain where it is under the immediate supervision of the engineering department. City Engineer Wightman believes it should be put under one of the commissions, perhaps that of water as the two are intimately combined in their operation. The engineering of the combined system should be in charge of the city engineer. Mr. Wightman recommends that the old sewerage system be at once remodelled to conform with the new; and the high level system, for which the Improved Sewerage System was originally designed to connect, be arranged; he thinks $500,000 would do it. The present system is operating admirably, as far as completed, and the cost of working it is about $50,000 per annum at present.

Contracts for 375,000 Tons of Coal.—MONTREAL March 23.—The Grand Trunk Railway Company have awarded contracts for the supply of 375,000 tons of coal required by them. Of this amount 250,000 tons are to be delivered at the Suspension and International bridges, 55,000 at Detroit, 20,000 at Sarnia, 20,000 at Brockville, and 30,000 at Portland Me. The rates are as follows: At the International Bridge, lump, $2.25 per ton: lump and nut, $2.20, and run of mine, $2.05; at Suspension Bridge, the same kinds of coal at $2.40, $2.35, and $2.20 respectively. The Detroit and Sarnia contract was awarded to the Cleveland, Lorain and Wheeling Railway at $2.05 at Detroit and $2.20 at Sarnia. The coal at Brockville is to be delivered by measure by Messrs. Bell, Lewis & Yates at $3.50. The coal for Portland was awarded to the Chesapeake and Ohio Coal Company at $3.50 per ton. Over 100 tenders were sumbitted.

Breakwater—Black Rock Harbor.—The following is an abstract of the bids for furnishing 7,000 tons of rip-rap stone for the construction of a breakwater in Black Rock Harbor, Conn., opened by Major McFarland on the 10th inst.:

Frank Pidgeon, New York, N. Y., $1.89 per cubic yard; total, $13,230.

Francis H. Smith, 16 and 18 Exchange Place, New York, N. Y., $1.94 per cubic yard; total $13,580.

Wm. Richardson & Co., Bound Brook, New York, $2.90 per cubic yard; total, $20,300.

John A. Bouker, 110 Wall Street, New York, N. Y., $1.22 per cubic yard; total, $8,540.

Samuel R. Cumming, New York, N. Y., $2.05 per cubic yard; total, $14,350.

Wm. H. Molthrop, Gales Ferry, Conn., Benjamin Stark, Jr., New London, Conn., and J. T. Tank, Chatham, N. Y., $2.24 per cubic yard; total, $15,680.

Charles H. Edwards, Boston, Mass., $1.96¾ per cubic yard; total, $13,755.

John Beattie, Leetes Island, Conn., $2.75 per cubic yard; total, $19,250.

Wm. E. Chapman, Brooklyn, N. Y., $1.33¾ per cubic yard; total, $9,362.50.

The contract has been awarded to the lowest bidder.

Dredging—Norwalk Harbor.—The following is an abstract of the bids opened by Major McFarland on the 10th inst. for dredging Norwalk Harbor, Conn.:

Frank Pidgeon, New York, 14¾c. per cubic yard; total $3,687.50.

Thomas Potter, Jersey City, N. J., 11 8-8c. per cubic yard; total, $2,972.22.

John McDermott, Cohoes, N.Y., 15 7-8c. per cubic yard; total, $3,968.75.

Richard M. Payn, Albany, N. Y., 14 5-8c. per cubic yard; total, $3,656.25.

J. H. Fenner, Jersey City, N. J., 18c. per cubic yard; total, $4,500.

Elijah Brainard, Jersey City, N. J., 10½c. per cubic yard; total, $2,625.

Morris & Cummings Dredging Company, New York, 13c. per cubic yard; total, $3,250.

Henry N. Beardsley, Bridgeport, Conn., 9 7-8c. per cubic yard; total, $2,468.75.

Contract awarded to Mr. Beardsley.

Dredging—Bridgport Harbor.—The following is an abstract of the bids for improving the harbor at Bridgport, Conn., opened by Major McFarland on the 10th inst.

Frank Pidgeon, New York city, 12 9-10c. per cubic yard; total (25,000 cubic yards), $3,225.

John McDermott, Cohoes, N. Y., 9½c. per cubic yard; total, $2,375.

Henry Du Bois' Sons, New York city, 7½c. per cubic yard; total, $1,875.

J. H. Fenner, Jersey City, N. J., 12c. per cubic yard; total, $3,000.

Morris & Cummings Dredging Company, New York city, 13c. per cubic yards; total, $3,250.

Henry N. Beardsley, Bridgeport, Conn., 9c. per cubic yard; total, $2,250.

The contract has been awarded to the lowest bidder.

Fighting Over Contract Dividends.—NEW YORK, March 16. Michael J. Dady's suit against Thomas McCann to have himself declared a partner in a contract for constructing $1,000,000 worth of sewers in Washington attracted many persons to the City Court of Brooklyn this morning. Mr. Dady testified that about July 15, he noticed an advertisement for bids for laying pipes in the District of Columbia, and he made estimates as to the cost of the work on which to make the 10 per cent. deposit. He showed the estimates to McCann, who wanted to share in the venture. This was agreed upon, and the witness went to see Mr. Hazzard, President of the Brooklyn City Railroad Company, and asked him to assist them in procuring a certified check for $70,000 or $80,000. The bid of Dady & McCann was accepted, and a certified check for $60,000 was accepted as security. They mutually agreed to execute an agreement between them when they reached Brooklyn. They felt that they would get a handsome profit out of the contract, but on returning to Brooklyn Dady heard from different sources that McCann was repudiating his (Dady's) connection with it. McCann pretended to desire to throw up his contract, and Dady offered to "go it alone," give McCann $1,000, and find the collateral for the certified check. The sewer was to be laid by next December, and the contract required the employment of about 400 men. Dady thought the contract was worth $50,000. He offered McCann $20,000 to give up his share. The offer was not taken. Counsel for defendant tried to show that a suit brought in Washington by Dady against McCann was a perfect bar to this action, but he was not sustained. The case was not ended.

Railroads, Bridges and Canals.

Organizing a Company.—The line for the proposed Saugatuck Valley Railroad, extending from the depot of the New Haven Railroad at Westport, Conn., and following the bank of the Saugatuck River to Redding, sixteen miles, was surveyed about a year ago and found feasible. The river abounds in fine water privileges its entire length, and the road, if built, will open up a country of great fertility. Articles of association of the Westport and Redding, more familiarly known as the Saugatuck Valley Railroad Company, were filed in the office of the Secretary of State, at Hartford, recently. The principal office will be at Westport. The capital stock is $500,000, in shares of $100 each. The directors are Horace Staples, president of the First National Bank; Edward H. Nash, Andrew C. Nash, Miller Ketchum, all of Westport; W. E. Allen, Bridgeport; John S. King, S. V. Sidell, William H. Wiley, of New York; Thomas N. Browne, of Brooklyn. John S. King subscribes for 400 shares, Miller Ketchum 380 shares, and thirty other subscribers one share each.

The Sharon & State Line Railroad has been chartered at Harrisburg, Pa., with $60,000 capital. This new road will connect the city of Sharon with the Mahoning division of the New York, Pennsylvania & Ohio Railroad.

Pensacola & Memphis R. R.—MONTGOMERY, ALA., March 19.—Articles of incorporation were filed to-day with the Secretary of State authorizing the formation of the "Pensacola and Memphis Railroad Company of Alabama." The road will run from Pensacola to Memphis via Meridian, Miss.

Iron R. R. Ties.—A company has been organized at Allegheny, Pa., for the manufacture of iron ties. These ties are angular in form and hollow. It is said that Reading has used them about a year with satisfactory results.

Changing Gauge.—The announcement is made that in June next the gauge of the Erlanger roads, better known as the Queen and Crescent route, will be changed to standard gauge. In June, 1886, if not before, the Louisville and Nashville will follow suit, and thereafter will be a standard gauge system.

Extension of the Central Pacific.—President Adams confirms the report published in the *Globe-Democrat*, St. Louis, that a survey for an extension of the Central Branch to a connection with the Kansas Pacific is in progress, but says thas nothing definite as to the time of constructing the same has been determined upon.

Hudson River Tunnel.—It is reported that the Hudson River Tunnel, upon which $1,100,000 have been expended thus far, will receive such additional aid from the Baltimore and Ohio Railroad Company that the work will be pushed forward to completion. The cost is estimated at $10,000,000.

Chesapeake & Nashville R. R.—The preliminary survey has been made to Danville, Ky., from Scottsville Ky., also a line joining at Hustonville to Stanford, Ky. The party under Chief Eng. Spradlin return to Adair and Barren Counties to run trial lines, and thence back to Gallatin, Tenn. The route has been found practicable and suited for a good road.

A Niagara Falls Railroad.—The Ontario Parliament is passing a bill to authorize a railway from Niagara Falls to Queenstown, on the Canadian side. A correspondent of the Toronto *Mail* reminds the promoters that they must pass through the Government Reservation at the Falls, and must get permission to do this from the Department of Railways and Canals.

Cairo & Delphos R. R.—PAINESVILLE, OHIO, March 19. General J. S. Casement, of this city, has just closed a contract for the construction of four hundred miles of railroad between Delphos, Ohio, and Cairo, Ill., the line being an extension of the Texas and St. Louis railroad. Work will be commenced at once. The tracklaying and ballasting portion of the contract will be done by C. E. Parker, of Ottumwa, Iowa, and A. T. Wilcox, of Monroe, Mich.

Pensacola & Memphis R. R.—Charters have been obtained at Pensacola, Fla., to construct a railroad to be known as the Pensacola & Memphis Railroad, which road, when finished, will give the North and Northwest the shortest and most direct outlet to the Gulf, and to the Memphis trade a new territory for distribution. Surveyors will take the field within a few days. The road will be built most likely by way of Meridian, Miss.

Kansas Railroads in 1884.—The annual report of the State Board of Railroad Commissioners of Kansas, presented to the Governor on Saturday, says that railroad building in Kansas has been much less active the past year than it had been for several years previous, and upon several of the leading lines of systems of railroads there has been a material falling off of earnings, compared with the preceding year. Nine roads show an insufficiency of earnings to pay the annual interest upon the bonded debt on a total capital stock of $264,000,000. The gross earnings for the past year were $62,000,000, and total expenses $60,000,000.

The Galesburg, Lacon & Chicago Line.—GALESBURG, ILL., March 14.—There has just been filed with the Circuit Clerk for record the articles of organization of the Galesburg, Lacon & Chicago Railway. Galesburg is to be the starting point of the new line. From here it will extend through Knox, Peoria, Stark, and Marshall Counties, to Sparland or Lacon, in Marshall County. The organizers of the company, who are also to be the first Board of Trustees, are Charles S. Cleaver, Edwin C. Markham, Jonah S. Seovel, Edgar G. Barrett, and G. E. Harmon, all of Chicago.

Trying to Revive a Cable Road.—Another effort was made on March 23 to revive the Brooklyn and Long Island Cable Railroad project in a petition by the company to the Brooklyn Board of Aldermen asking for a franchise. The conditions made by the company are that the roads shall be completed from Washington and Sands Streets and from the South Ferry to Flatbush-avenue within 18 months, to a point east of Brooklyn-avenue within three years, and to the city line within five years.

The Chicago, Burlington & Kansas City R. R., is extending its line eight miles to Carrolton, Mo. Contractors are now at work, and the line is to be completed by August 1.

The Henderson Bridge on the Ohio river is rapidly nearing a finished condition. Three spans on the Kentucky and five on the Indiana sides are now in position. The masonry is not yet complete, but a week of good weather will perfect that. The bridge contains five spans of 120 feet, five of 249 feet, two of 250 feet and the channel span of 525 feet. This latter is claimed to be the longest truss span in the world. There have been expended to date $1,200,000. The probable cost will be $1,500,000. The work will be finished and the bridge opened by June 1, if no trouble is encountered from high water.

Burlington Extension.—DENVER, COL., March 16.—The report from San Francisco to-day that the Chicago, Burlington and Quincy intend to parellel the Union Pacific between Denver and Ogden is generally believed here. Three gangs of surveyors are at present actively engaged at work surveying on the line in Western Colorado. The officials of that road here do not deny that their Company has surveyors at work in Western Colorado, but say they are only laying out a feasible route for obtaining possession of mountain passes, etc., so that in case the company does decide to build across Colorado, it will find no impediments in the way of their progress.

The Honduras Railway.—Mr. S. B. Connico, president of the Honduras road, which is now being surveyed from Truxillo to Puerto Cortez, is now in receipt of a letter from Captain Abram Cutler, the chief engineer, dated at Truxillo, on January 22.

In his letter Captain Cutler states that he has completed the fifty-fifth mile of the survey, and to that point the actual survey shows that the distance is eleven miles shorter than was estimated prior to the commencement of the survey. The country is wonderfully level, and the profile of the land as far as surveyed shows that the cost of building the road-bed will not amount to more than $2,500 per mile.

Captain Cutler is loud in his praise of the resources and fertility of the country, and gives a very interesting description of the forests owned by the roads, and other wealth which lies in the raw woods—fruits and fiber plants which are natives to the soil.

The Cleveland Southern.—The incorporators of the Cleveland Southern Road organized by the election of the following officers on March 14: President, Mr. A. J. Brockett,; Vice President, J. B. Glenn; Secretary, Abner Slutz; Treasurer, D. B. Wick; General Manager, George Hester. The required 10 per cent. of the $250,000 of stock was subscribed and the future policy of the road was outlined. It was determined to make arrangements for a survey as soon as possible. Mr. Slutz said that no efforts had been made in New York toward raising capital, but that gentleman stood ready to enlist capital as soon as it may be needed. "The advantage of this line, aside from the fact that it taps a rich mineral field," said Secretary Slutz, lies in the fact that it does not come into competition with any other line, but being twenty miles on either side from any other road, it has the field to itself.

Georgia & Florida R. R. Notes.—Ten days more of fair weather will be sufficient to complete the grading of the Americus, Preston and Lumpkin Railroad from Americus to Lumpkin.

Work on the new road from Lake City to Gainesville has commenced in earnest.

Work upon the Silver Springs, Ocala and Gulf Railroad, it is stated, will be commenced in a few days. The officers of the road are: T. C. Hoge, of New York, President; Myron P. Walker, of Boston, Vice President; Oscar Tamaquo, of New York, Treasurer; I. Parish, af New York, Secretary.

It is rumored that application will be made for a charter to build a railroad from Augusta to Chattanooga, Tenn., passing the gold and silver belt in Murray county, via Spring Place, and running thence to Cohutta, where it will connect with the East Tennessee, Virginia and Georgia Railroad.

The construction of the new Indian River and Florida Railroad from Enterprise to Titusville is considered settled. The route has been surveyed, and the engineers' reports are said to be most encouraging.

One of the most important cases just decided by the State Supreme Court is the case of the Port Royal Railroad against the city of Augusta. The Port Royal and Augusta Railroad Company claimed the right to go through the streets of Augusta in order to connect with the Georgia Railroad and Central systems. The municipal authorities refused to allow the road to go through the streets, and threatened to arrest the workmen if it was attempted. The road filed a bill of injunction, and the court below sustained it, holding that the road had the right to go through the streets of the city. The Supreme Court on Tuesday reversed the judgment, holding that the railroad company had no right to run its tracks through the city without the consent of the Council, and that the Council could not be required to give consent if it deemed it best to withhold it.

Index to Periodical Literature.

Asbestos. *Asbestos.*—The method of quarrying, preparation for market, and manufacture into yarn, cloth, etc., with mention of the various uses to which it is put; illustrated. *Engineering*, March 6, 1885, pp. 231 and 232.

Bridge Accident. *Fall of a Bridge during Construction.* Account of the accident to a bridge while being built over the Brandywine Creek, near Wilmington, Del., on the Baltimore & Ohio R. R. Description and illustration of the temporary trestlework. *Engineering*, March 6, 1885, p. 248.

Bridge Calculations. *A New Formula for the Calculation of Draw-Bridge Strains.* The writer gives a formula which he claims is free from various sources of error which he points out as pertaining to previous formulæ. The calculations are given in full. By F. Beresford, C. E. *Van Nostrand's Eng. Mag.* Mar., 1885, pp. 137 to 144.

Bridge Works. *A Canadian Bridge Works.* A general description of the Dominion Bridge Co's. works, near Montreal, showing the disposition of the machinery, and the methods of applying power. Coal gas fuel is used, and steam is generated at a central station and transmitted to small engines located where needed. *Iron Age*, Feb. 12, 1885, pp. 9 and 11.

Canal, Nicaragua. *The Nicaragua Canal Project.* An editorial discussion of the proposed project, in which the comparisons drawn with the Panama project and are all favorable to the Nicaragua project. *Engineering*, Mar. 6, 1885, pp. 243 and 244.

Electrical Transmission. *The Transmission of Power by Electricity.* Treats in a general way of the underlying principles of Magneto-electric and dynamo-electric machines, electro-motors, electrical transmission theoretically considered, practical applications, and concludes with some speculations. By Robt. Luce. *Van Nostrand's Eng. Mag.*, Feb., 1885 pp. 154 to 165.

Elevated Railroads, *see* **Railroads, Elevated.**

Railroad Cars.—*Saloon Carriages for Buenos Ayres Great Southern Railway.* A description, with detailed illustrations, and a table of principal dimensions, of a sleeping car designed by an English engineer and built by an English firm. The length of the body is 29 feet, and it is divided into three compartments. *Engineering*, March 6, 1885, pp. 242 and 251.

Railroads, Elevated—*Elevated Roads.* A report by expert engineers on the strength and safety of the structures of the elevated railroads of New York, accompanied by an elaborate report by Prof. Thurston on the effect of repeated shocks on the quality of iron. By A. P. Boller, T. C. Clarke and others. *N. Y. Mail and Express*, March 21, 1885.

Railway Telegraphing.—*The Phelps System of Telegraphing from a Railway Train while in Motion.* The system is based on the principle of "electrical induction." A telegraph wire is laid in the center of the railway track; another is attached to the bottom of a car, parallel to and a few inches from the former. The latter is connected with a telegraph sounder in the car, which is operated by the induced current. Described and illustrated in *Scientific American*, Feb. 21, 1885, pp. 118, 119.

Rainfall.—*Analysis of the Rainfall at Lake Cochituate, Mass.* The observations cover a period of 33 years, and the results as analysed are shown by tables and diagrams. Results for other localities are also shown graphically. By Desmond Fitzgerald; with discussion. *Trans. Am. Soc. Civil Engineers*, Nov. 1884, pp. 359 to 371.

River Improvements.—*See* Jetties, Levees.

River Improvement—Seine.—*Le Barrage et les écluses de Luresnes.* Description of the dam and locks erected at Luresnes for securing constant navigation of the Seine, at all seasons, between Paris and Rouen. Fully illustrated with a general view, plans, sections, etc. *Le Genie Civil*, Jan. 31, 1885, pp. 220 to 222.

Sanitary.—*On the Influences Which Principally Affect the Purity of Air in Towns.* A statement of the causes which contribute to the floating matters in the air, the necessity of diminishing these impurities, with some suggestions of remedies. A paper read before the Ass'n. of Public Sanitary Inspectors (England.) by Captain Douglas Dalton. *Sanitary World*, Feb. 21, 1886, pp. 237 to 239.

Sea-Wall. Brighton.—*Brighton Beach Works.* A description of the Sea-wall recently constructed at Brighton Beach, England, with a consideration of its probable effect on the adjacent beaches. The wall is faced with moulded blocks of concrete which are themselves faced with flints, carefully pointed with Portland cement. Illustrated. *Engineer*, Feb. 13, 1885, p. 126.

Sewage Disposal at Leyton, England.—The sewage is treated with black-ash waste. Method of working, and results obtained, with cost of works. Condensed from paper by W. Dawson. *Sanitary Engineer*, Mar. 5, 1885, p. 289.

Sewerage of a Small City.—Extracts from a report on the sewerage of Marlboro, Mass., in which sewers are recommended for house drainage only, and the disposal of the sewage on the land by irrigation. The statements quoted will apply to many other growing towns similarly situated. By E. S. Philbrick. *Sanitary Engineer*, Feb. 26, 1885 pp. 269, 270.

Stadia Reduction Tables.—*Tables of Horizontal Distances and Differences of Elevations for Stadia Measurements*, for every two minutes up to 31°; based on Mr. Geo. J. Specht's formulæ. By Arthur Winslow. *Proc. Eng. Club of Phil.*, Nov. 1884, pp. 248 to 255.

Steel.—*The Clapp-Griffiths Process.* Two papers descriptive of the process, read before the Am. Inst. of Mining Engineers. By J. P. Witherow and Robt. W. Hunt. *Iron Age*, Feb. 26, 1885, pp. 18 and 27.

Steel.—*The New Clapp-Griffiths Steel Plant at Pittsburgh.* A detailed description, with illustrations, plans, erections, etc., of the earlier and later forms. *Iron Age*, March 12, 1885, pp. 1 and 15.

Steel Springs.—*The Resilience of Steel.* The writer experimented with various steel springs with a view to determine their adaptability as a motive power for street cars. He obtained higher results than any previously recorded, but so low as to show that this method of propulsion will fail to work practically and economically. By Wilfred Lewis. *Proc. Eng. Club of Phil.*, Nov. 1884, pp. 226 to 232.

Stone, Artificial.—*Victoria Stone.* An artificial stone made by forming a concrete of small granite spawls and Portland cement, which is petrified by immersion in solution of silica in caustic soda. The stone has been very satisfactorily used in England for paving, architectural, and other purposes. Its manufacture is described and its applications and advantages stated. *Sanitary World.* See also *Am. Arch. and Bld'g News*, Feb. 28, 1885, pp. 104 and 105.

Strength of Materials—*On the Strength of Materials Under Repeated Stress.* A discussion of the experiments of Wohler and Spangenburg on the effect of repeated varying stress, with the laws established therefrom. A formula for the unit stress which will cause rupture after an enormous number of repetitions is also deduced. By Prof. Mansfield Merriman. *Van Nostrand's Eng. Mag.*, Feb. 1885, pp. 96 to 98.

Tide Predicting Machine.—*Description of a Maxima and Minima Tide-Predicting Machine.* The mathematical theory of the machine is first given and then a detailed description of the machine. Fully illustrated. By Wm. Verrol, *Am. Rep. of U. S. Coast and Geodetic Survey*, 1883, App. 10, pp. 293, 272.

Tides Theory of—*On Tidal Theory and Tidal Predictions.* This paper contains a discussion of the first part only of the subject—tidal theory,—leaving the other part to be discussed in a future paper. The tide-generating forces are considered in detail. By E. A. Gieseler. *Jour. Franklin Institute*, March, 1885, pp. 161 to 188.

Market Report of Engineering Materials.

New York, March 26, 1885.

NOTE.—The following Market Report gives wholesale prices on the New York Market unless otherwise stated. It is intended as a general guide to the estimating engineer, and both the range of material and the market location will be extended as rapidly as possible. We give it with this caution, that, as is well understood in business transactions, the amount of bill, distance from market centre and conditions of payment will have a material influence on the final paying prices.

IRON.

STRUCTURAL IRON.			
Angles		2.2c. @	2.6c.
Tee		2.8c. @	3c.
Beams and channels		3.0c. @	3.5c.
Tank		2.1c. @	2.15c.
Shell		2¾c.	
Steel plates, Tank		3c. @	3½c.
WROUGHT-IRON PIPE. PITTSBURGH.			
Butt welded, black	Discount	50	
" " galvanized	"	40	
Lap welded black	"	50	
" Galvanized	"	67½	
Boiler tubes	"	60	
RAILS.			
Steel (large lots at mill)		$26 @	26.50
Old rails		17. @	17.50
Old rails, steel		16 @	17
R. R. spikes			3c
R. R. splice-plates		1.65c. @	1.75c.
R. R. Track Bolts		2.35c. @	2.65c.
Barb-wire fencing, galvanized		4⅞c. @	5¾c.
" " painted		3¾c. @	4¼c.
Corrugated iron			
Nails			
Iron		2.25	
Steel		2.35	

METALS.

COPPER.		
Lake Superior	11 @	.11¼
Other Brands	10¾ @	10¾
LEAD.		
Com. Domestic	3.60 @	3.70
Lead Pipe	.06¾	
Tin-Lined Lead Pipe	.15	
Sheet Lead	.06¾	
ZINC.		
Sheet	5.15 @	5.25

BRICK.

(Cargoes afloat)		
Haverstraw 1st, per M.	$6.00 @	6.25
" 2nd "	5.62 @	5.87
Fishkill	4.75 @	5.50
Up-River		
Jerseys	5.25 @	
Long Island		
" pale		
FRONTS.		
Croton red	14.00 @	
" dark	14.00 @	
" brown	12.00 @	
Philadelphia pressed	22.50 @	23.00
Trenton "	22.50 @	23.00
Baltimore "	37.00 @	41.00
Buff "	33.00 @	35.00
Enameled English	65.00 @	130.00
" American	85.00 @	120.00
Fire brick	25.00 @	40.00

CEMENT.

PORTLAND.		
Robins & Co., Extra English 425 lbs. per bbl.	2.75 @	2.90
K. B. & S. English 400 lbs	2.85 @	3.00
Burham " "	2.70 @	2.85
Rochester Castle " "	2.50 @	2.60
J. B. White & Bro. " "	2.50 @	2.60
Other brands, " "	2.40 @	2.50
Keene's fine " "	9.50 @	9.75
" course " "	5.25 @	5.50
Roman	2.75 @	3.50
Dyckerhoff, German 400 lbs	2.60 @	2.65
Star, " "	2.60 @	2.65
Alsen, " "	2.55 @	2.60
Hanover " "	2.40 @	2.50
Other brands, " "	2.35 @	2.40
Saylor's American	2.15 @	2.50
F. O. Norton	1.10	
Rosendale cements	0.90 @	1.00

LIME.

Rockland common per bbl	1.00	
" finishing	1.20	
Glensfalls, common	.85	
" finishing	1.05 @	1.10
Kingston, ground	0.95	

STONE.

Cargo rates at New York.		
Amherst freestone, No. 1 per cub. ft.	0.90 @	95
" " No. 2 "	0.75 @	0.80
" " light drab "	0.80 @	0.95
Berlin " in rough "	0.75 @	1.00
Berea " "	0.75 @	1.00
Brownstone, Portland, Ct. "	1.00 @	1.30
" Belleville, N. J. "	0.75 @	1.25
Granite, rough	0.60 @	1.25
Common building stone per load	2.00 @	3.00
Base stone, from 2½ to 6 ft. lengths, per lin. ft.	0.40 @	3.00

SLATE.

Purple roofing per square	6.00 @	7.00
Green "	6.00 @	7.00
Red "	15.00	
Black Penna. (at New York) "	4.50 @	5.00

LUMBER.

PINE, Common box per M.	18.00 @	20.00
Good "		
Tally plank, 1¼ in each.	.44 @	.50
Tally boards, dressed "	.28 @	.30
SPRUCE, Boards dressed "	.25 @	.28
Plank, 1¼ in "	.28 @	.30
" 2 in. "	.38 @	.40
" 2 in. dressed "	.43 @	.45
Timber per M.	20.00 @	22.00
HEMLOCK, Boards each.	.18 @	.20
Joist, 2½ × 4 to 4 × 6 in	.17 @	.44
OAK per M.	55.00 @	65.00
CYPRESS 1, 1¼, 2 and 2¼ in "	35.00 @	40.00
YELLOW PINE, Girders "	26.00 @	35.00
Dressed flooring "	30.00 @	40.00
SHINGLES, Extra shaved pine, 18in. "		
" sawed 18 in. "	4.50 @	5.00
LATH, Cargo rate "	2.50 @	2.60

PAINT.

Lead, white, American dry per lb	.04¾ @	.05
" " in oil pure "	.05½ @	.05¾
English, B. B. in oil	.08½ @	.08¾
Red, American "	.05½ @	.05½
Litharge "	.05 @	.05½
Venetian red, American "	.01 @	.01½
Indian red "	.05 @	.10
Vermillion, American lead "	.11 @	.11½
Paris green "	.15 @	.19
Umber, Amer. raw and powdered per lb.	.01¼ @	.01½
Drop black, Amer. "	.08 @	.12
" " "	.09 @	.11½
Chrome green	.05 @	.15
Oxide zinc, American	.03¼ @	.04
" French	.06¼ @	.06½

TEXARKANA, Ark. and Tex. have issued franchise to Mr. F. Wm. Raeder of St. Louis, Mo., for erection of water-works. To be started very soon.